

Engineering Physics Laboratory Manual
(Common for All B. Tech Courses)



HEAS Department
University Department

Rajasthan Technical University, Kota



Vision of HEAS Department

To provide a sound foundation to the undergraduate students by giving Quality education in basic sciences along with moral ethics and effective communication skills to become competent engineers of tomorrow's to serve the society.

Mission of HEAS Department

The Department is committed to train the young graduates in basic sciences and inculcate ethical values and social responsibilities through an innovative teaching and learning methodology.



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CO's and PO's - PO's Mapping

Credit: 1
0L+0T+2P

Max. Marks: 75
(IA: 50, ETE: 25)

Course Outcome for Engineering Physics Laboratory Classes

The students should be able to:

CO1	Develop the experimental skills and thinking capabilities.
CO2	Describe different phenomenon related to optics, Electronics and material science through experimentation.
CO3	Implement the theoretical concepts of optics and electronics through experimentation.

CO-PO Mapping for Engineering Physics Laboratory Classes (3-Strong, 2- Moderate and 1- Weak)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	1	-	-	-	-	-	1
CO2	3	2	-	-	-	1	-	-	-	-	-	1
CO3	3	2	-	-	-	1	-	-	-	-	-	1



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Program Outcomes (POs) (Common to all Branches):

PO1	Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective report sanded sign documentation, make effective presentations and give and receive clear instructions.
PO11	Project management and finance: Demonstrate knowledge and Understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.



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Instructions for the students

- Students are required to prepare two identical Physics practical note books. One shall be day to day note book in which one has to record observations (observation book) and another shall be usual one for recording the complete experiment (Record Book). It is the Record Book which is to be signed by the teacher after the completion of the practical where a after recording observation of the practical observation book is to be signed by Lab. Assistant/Teacher.
- Students are required to bring their practical record books (Both) at every turn, failing which they may not to be permitted to perform the experiment.
- The details of both the notebooks are as follows :

OBSERVATION NOTE BOOK:

For each Experiment

- (i) Write Object
- (ii) Write Experiment number
- (iii) Make all observation tables in which observations are to be recorded.
- (iv) Before leaving the laboratory at each time, do not ever forget to get the recorded observations signed by the Lab Assistant / Teacher.

RECORD BOOK:

- (a) Write down the complete list of experiment to be performed in the laboratory, at the start of the book.
- (b) After completing each experiment, record it as follows :
- (c) Experiment number and Date
- (d) Object
- (e) Apparatus
- (f) Illustrated formula with notification explained and unit in which quantities are measured.
- (g) Labeled figures / diagrams/circuit diagrams (on first left hand page and to be drawn by pencil.)
- (h) Observation Tables.
- (i) Calculation.
- (j) Result with unit.
- (k) Precautions, Comments (actually taken) and Criticism

Note: Method / Procedure are not to be written in record book.

- Fill in the index of the record book for the experiment to be checked.
- Grade on the index page of the record book will be awarded on the quality of work and knowledge acquired.
- Get the book signed by the teacher and obtains the grade for each experiment on index page of the book.
- Students will be allotted new experiment one turn earlier. They should read about the experiment and precaution there in before starting the experiment.
- Students will not be allowed to do next experiment if the previous experiment has not been completed in all respect.
- The write ups of all experiments are available in the lab. These write ups are only guidelines to help the student to perform the experiment.
- Students are required to get issued the apparatus and experiment write ups from the Laboratory attendant by producing a slip mentioning the name of experiment and write ups required by the student. The apparatus and write-ups are to be returned back before leaving the lab.
- Students shall handle the apparatus carefully and they should know the details of the apparatus they are using. Mishandling the apparatus careless work or stealing goods shall induce penal action.
- Students should not touch the optical surfaces of the optical instruments i.e. that of Prism Grating surfaces Lenses eye pieces etc.
- Students are not allowed to displace/interchange /remove any apparatus from their normal position without prior permission.
- Students are required to disconnect electrical connection after completion of the experiment. While using primary cell, please take out emulated zinc rod from the cell when not in use.
- Students are expected to perform all practical given in the list. Please note carefully that in examination no change of practical is allowed.



LIST OF EXPERIMENTS

1. To determine the wave length of monochromatic light with the help of Michelson's interferometer. **[K3 Level; CO3]**
2. To determine the wave length of sodium light by Newton's Ring. **[K3 Level; CO3]**
3. To determine the wave length of prominent lines of mercury by plane diffraction grating with the help of spectrometer. **[K3 Level; CO2]**
4. Determination of band gap using a P-N junction diode. **[K3 Level; CO1]**
5. To determine the height of given object with the help of sextant. **[K3 Level; CO1]**
6. To determine the dispersive power of material of a prism with the help of spectrometer. **[K3 Level; CO3]**
7. To study the charge and discharge of a condenser and hence determine the same constant (both current and voltage graphs are to be plotted). **[K1 Level; CO2]**
8. To determine the coherence length and coherence time of laser using He – Ne laser. **[K3 Level; CO1]**
9. To measure the numerical aperture of an optical fibre. **[K3 Level; CO3]**
10. To study the Hall Effect and determine the Hall Voltage and Hall coefficients. **[K3 Level; CO1]**



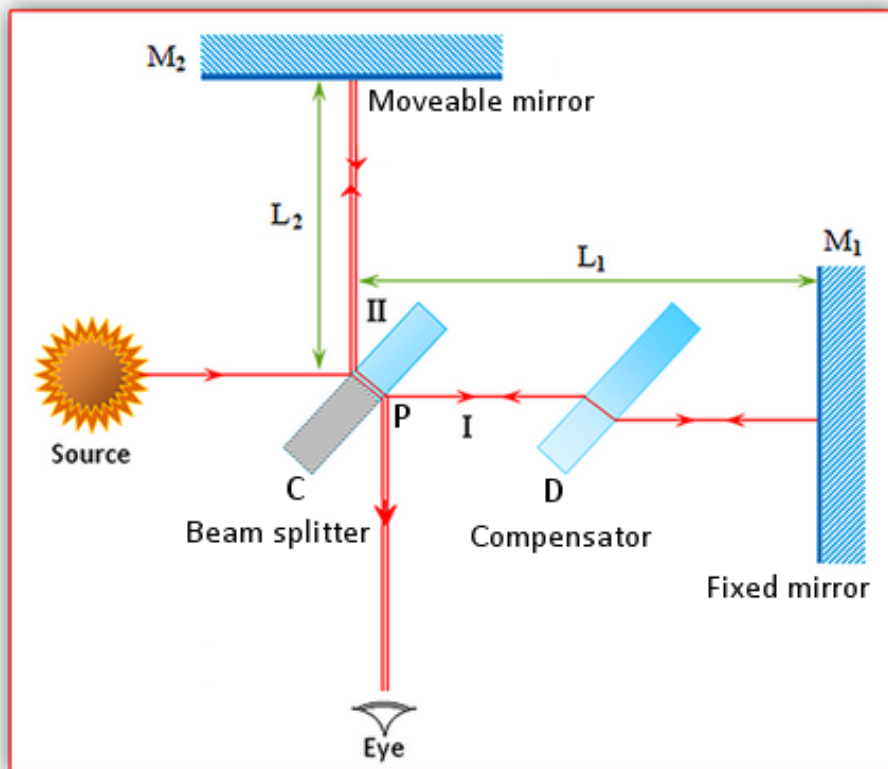
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EXPERIMENT-1

OBJECT: To determine the wavelength of sodium light using Michelson's interferometer.

APPERATUS: Michelson's Interferometer, sodium lamp, convex lens and reading lamp.

DIAGRAM:



THEORY & FORMULA:

The interference developed by Michelson's interferometer is by division of amplitude of ray generated from a monochromatic source of light. The wavelength of sodium light can be determined by the following formula

$$\lambda = \frac{2(x_2 - x_1)}{N}$$

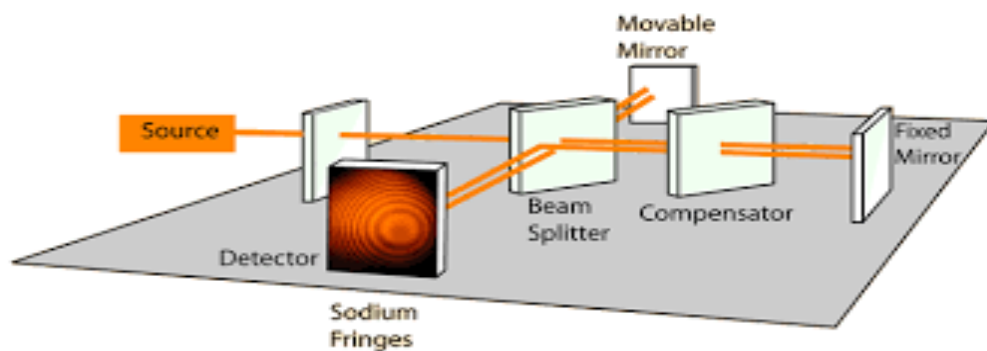
Where x_1 = Initial position of mirror M_1 of Michelson's interferometer in cm.
 x_2 = Final position of mirror M_1 of Michelson's Interferometer in cm.
 N = Number of fringes crossing the field of view of eyepiece.



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PROCEDURE:

1. Using a scale make the distance of mirror M_1 and M_2 from point O nearly equal.
2. Place a cardboard with a pin hole between sodium lamp and glass plate G_1 . Now see through the telescopic eye piece to observe two pair of images, one due to partial reflection at the unsilvered face of G_1 and the mirrors M_1 and M_2 respectively and another due to partial reflection at the half silvered surface of G_1 and reflection at mirrors M_1 and M_2 respectively. The second pair of images will be brighter than first one.



3. Use the tilting screws attached to mirrors into proper directions to coincide brighter images. Now remove the pinhole screen. To achieve the fringes adjust the screws attached to mirror M_2 and get circular fringes.
4. The mirror M_1 is attached with a micrometer screw (Screw gauge). Note the least count of this measuring device. Adjust the position of mirror M_1 to bring the centre of fringes at the centre of cross wire of eyepiece. Note down this position on the scale of micrometer screw.
5. Now shift the mirror M_1 to pass fringes in the field of view of eyepiece. Count the number of fringes and measure the corresponding position of mirror M_1 from the scale. This procedure can be continued for different number of fringes passing through the field of view of eyepiece.
6. Calculate the distance by which mirror M_1 has been shifted for different number of fringes as indicated in the observation table.
7. Finally use the formula to calculate wavelength from this data.



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OBSERVATION TABLE:

Least count of micrometer screw = cm.

S.No.	Number of fringes	Reading of micrometer screw						Value of $x = x_1 \cdot x_2$ in cm
		Initial position of mirror $M_1(x_1)$			Final position of mirror $M_1(x_2)$			
		MS(cm)	CS(cm)	Total	MS(cm)	VS(cm)	Total	
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

CALCULATIONS:

$$\lambda = \frac{2(x_2 - x_1)}{N}$$

RESULT:

The wavelength of sodium light is = cm = \AA ⁰
 Standard value =
 Percentage error =

PRECAUTIONS:

1. Do not touch the face of mirrors and glass plates.
2. While taking observations, micrometer screw should be turned in one direction to avoid back lash error.
3. The centre of fringes shall be at the centre of cross wire of eyepiece.



EXPERIMENT-2

OBJECT: To determine the wavelength of sodium light by Newton's ring.

APPARATUS: A plano convex lens of large radius of curvature, travelling microscope, optical arrangement for Newton's ring, Sodium lamp.

THEORY & FORMULA:

The mean wavelength of D1 and D2 lines of sodium light is given by

$$\lambda = (D_{n+p}^2 - D_n^2) / 4 p R$$

Where

D_{n+p} = Diameter of (n+p)th ring,

D_n = Diameter of nth ring

n and p = Integers,

R = given radius of curvature

PROCEDURE & DIAGRAM:

1. The glass plate G in the Newton's ring apparatus is set such that it makes an angle of 45° with the direction of incident light from the source and reflects the light on the lens.
2. The Plano convex lens is placed below the microscope with its plane surface upwards.
3. The microscope is moved in the vertical direction by means of rack and pinion arrangement till the rings are seen distinctly.

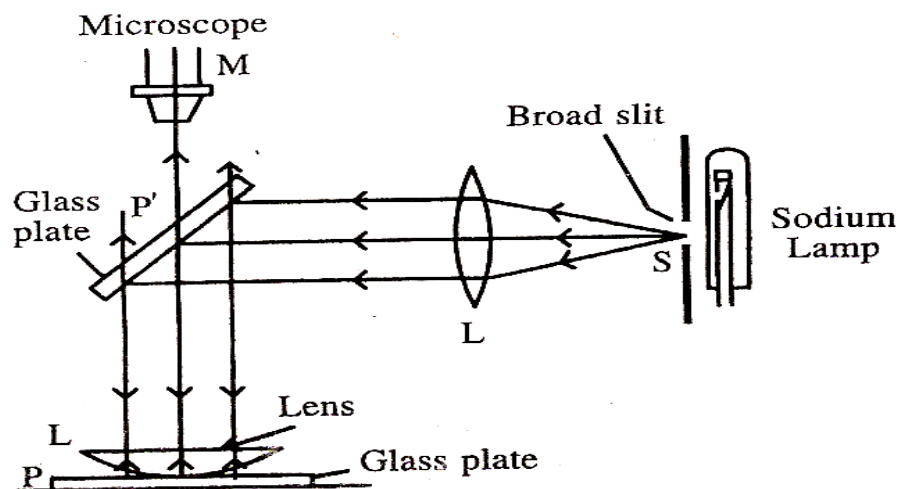


Fig. 1



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4. The centre of the fringes is brought symmetrically below the cross wires by adjusting the position of the lens and the microscope. The microscope is moved in horizontal direction to one side of the fringes such that one of the crosswire becomes tangential to the 22nd ring. The reading on the scale is noted.
5. The microscope is moved and the cross wire is successively made tangential to the 20th, 18th and so on till the 22nd on the other side is reached. The reading on the scale for all these position is noted.

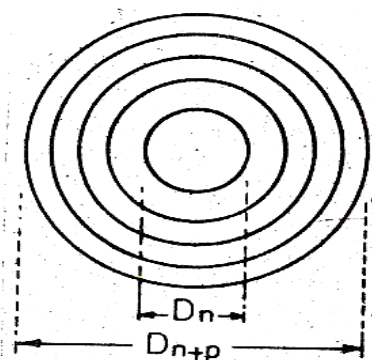


Fig. 2

OBSERVATIONS:

One division of main scale \times = 0.1cm
 No of divisions on the vernier scale n = 100
 Least count of the microscope \times/n = 0.001 cm

S. No.	No. of the rings	Microscope reading						Diameter $D=a-b$ cm	D^2 cm^2	$(D_{n+p}^2 - D_n^2)$ cm^2
		One end (a)			Other end (b)					
		m.s. cm	v.s. cm	Total reading a cm	m.s. cm	v.s. cm	Total reading b cm			
1.	22									
2.	20									
3.	18									
4.	16									
5.	14									
6.	12									
7.	10									
8.	8									

Mean value of $(D_{n+p}^2 - D_n^2) =$ cm^2 for $p = 8$



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CALCULATION:

$$\lambda = (D_{n+p}^2 - D_n^2) / 4 p R$$

Where i) Radius of Curvature = 110 cm

ii) $p = 8$

RESULT:

Mean wavelength of sodium light	=	A°
Standard value	=	5893 A°
Percentage error	=	

PRECAUTIONS:

1. The glass plate surface and the lens surface must be thoroughly cleaned otherwise the fringes will not be bright and sharp
2. The microscope's eyepiece must be properly focused on its cross wire.
3. In order to avoid backlash error, the microscope should be given motion only along one direction.
4. Number of fringes should be measured accurately



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EXPERIMENT-3

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

APPARATUS: Spectrometer, mercury lamp, diffraction grating, reading lens, spirit level etc.

THEORY: The wavelength of light emitted by the source is given by

$$\lambda = \{(e+b) \sin \theta\} / n$$

Where

λ = Wavelength of light, $e+b$ = Grating element
 θ = angle of diffraction n = order of spectrum

PROCEDURE:

(A) Setting of the Spectrometer:

1. Setting of the Telescope

(a) The telescope is first turned towards some white wall; the eyepiece is shifted w.r.t. The cross wires till a sharp image of the cross wires is obtained. The eyepiece is now fixed.

(b) The telescope is focused on a distant object and the parallax between the image and the cross wires is removed. Thus the telescope is set for parallel rays.

2. Setting of the collimator

The position of the lens of the collimator is adjusted such that a sharp and well-defined image is seen through the telescope.

3. Setting of the Prism table

The prism table is first made perfectly horizontal with the help of spirit level and the leveling screws. The height of the prism table must be on the axis of collimator and telescope.



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(B) Adjustment for determination of the angle of diffraction:

1. The telescope is turned towards left or right and the first line of first order spectrum is seen on the cross wire. The angular position of the telescope is determined with the help of both the verniers V1 and V2.
2. Now the telescope is turned in the opposite direction and again the first line of the first order spectrum is viewed on the cross wire. Again the angular position of the telescope is noted on both the verniers. The difference of two verniers taken above is equal to twice the angle of diffraction. Hence half of this difference gives the angle of diffraction θ .

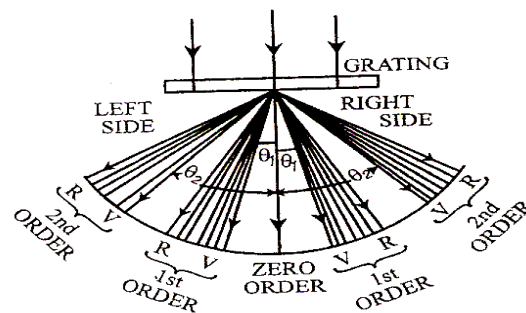


Fig 1

3. The grating element is determined from the number of lines per inch supplied by the manufacturer. Finally wavelength of each spectral line is determined from $(e + b)$, θ and n .

OBSERVATIONS:

(a) Determination the grating element:

Number of lines per inch on grating = 15,000

Grating element $(e+b) = 2.54/15,000 = 1.69 \times 10^{-4}$ cm.

Order of spectrum = 1

(b) Determination the angle of diffraction θ :

Value of the one division of vernier scale = 0.5 degree

Total number of vernier divisions = 30

Least count of the vernier = $0.5 / 30 = 1/60 = 1$ min.



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S. No.	Colour of light	Vernier	Towards right of the central image			Towards left of the central image			$2\theta = a-b$	θ	Mean θ
			M.S.	V.S. .	T.R. (a)	M.S.	V.S.	T.R. (b)			
1.	Violet	V1									
		V2									
2.	Green	V1									
		V2									
3.	Yellow	V1									
		V2									

CALCULATIONS:

(A) For violet Colour, $\lambda_V = \{(e+b) \sin \theta\} / n =$

(B) For green Colour, $\lambda_G = \{(e+b) \sin \theta\} / n =$

(C) For yellow Colour, $\lambda_Y = \{(e+b) \sin \theta\} / n =$

RESLUT:

Mean Wavelengths

$\lambda_V = \dots\dots\dots, \lambda_G = \dots\dots\dots, \lambda_Y = \dots\dots\dots$

Standard value: $\lambda_V = 4358 \text{ \AA}, \lambda_G = 5460 \text{ \AA}, \lambda_Y = 5790 \text{ \AA}$

Percentage error =

PRECAUTIONS:

1. The slit should be as narrow as possible but the knife-edges of the slit should not touch each other.
2. The telescope and the collimator should be separately set for parallel rays.
3. Grating should be set normal to the incident light
4. While taking observations the telescope and the prism table must be clamped.



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EXPERIMENT-4

OBJECT: Determination of band gap using a P-N junction diode.

APPARATUS: PN junction diode, micrometer (0-50) μA , battery, thermometer and heater.

THEORY & FORMULA:

If I be the reverse current flowing through pn junction diode at temperature T , then

$$I = A_s \exp [-q \Delta E_g / KT]$$

or
$$\log_{10} I = \log_{10} A_s - 5.036 (\Delta E_g) 10^3 / T$$

Where ΔE_g in V.

The graph plotted between $\log_{10} I$ and $10^3/T$ comes out be a straight line as shown in Fig. 2 whose slope is given by

$$AB / BC = 5.036 (\Delta E_g)$$

or
$$(\Delta E_g) = 0.198 AB / BC$$

PROCEDURE:

1. The electrical connections are made as shown in the diagram Fig. (1). It should be noted that positive terminal of the battery is connected to N and negative terminal to P terminal of the diode for reverse bias.

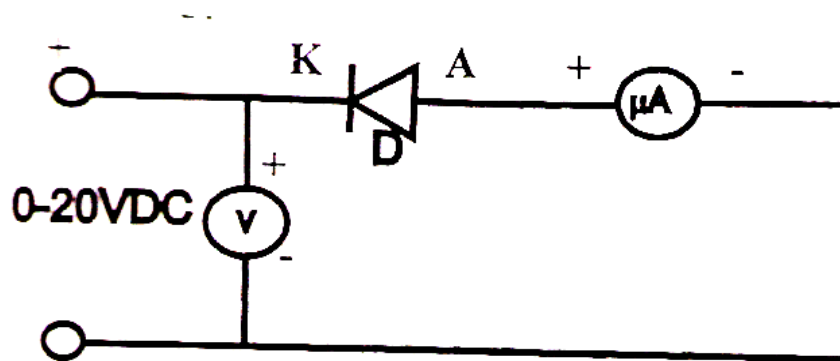


FIG. 1

2. Heater is heated in a calorimeter up to $70^\circ\text{-}80^\circ\text{C}$. The temperature is noted for various values of current as the diode cools down.



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

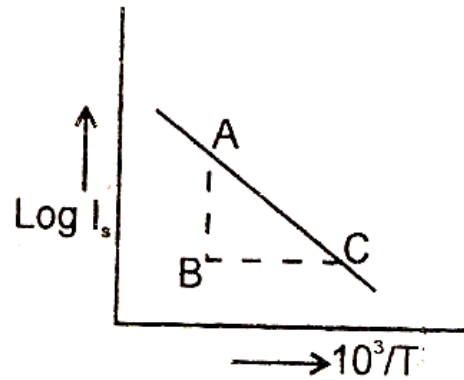


Fig. 2

OBSERVATIONS TABLES:

S. No.	Current I (μA)	Temperature of diode T		$10^3/T$	$\log_{10}I$
		in $^{\circ}\text{C}$	in K		
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

CALCULATIONS:

From the graph,

Slope = $AB / BC =$

Energy gap $\Delta E_g = 0.198 AB / BC = \dots\dots\dots\text{eV}$



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RESULT & CONCLUSIONS:

The energy band gap for a given semiconductor =eV

Standard value for Germanium = 0.72 eV

Standard value for Silicon = 1.10 eV

Percentage error =

PRECAUTIONS:

1. The diode should be reverse biased.
2. The reverse bias should not be increased beyond a certain limit otherwise it may get damaged.
3. The cooling rate should be slow so that the diode gets necessary time to attain the temperature of the liquid.
4. The liquid should not be heated beyond 70°-80°C.

EXPERIMENT-5

OBJECT: To determine the height of given object with the help of sextant.

APPARATUS: A Sextant, Measuring Tape etc

DIAGRAM:

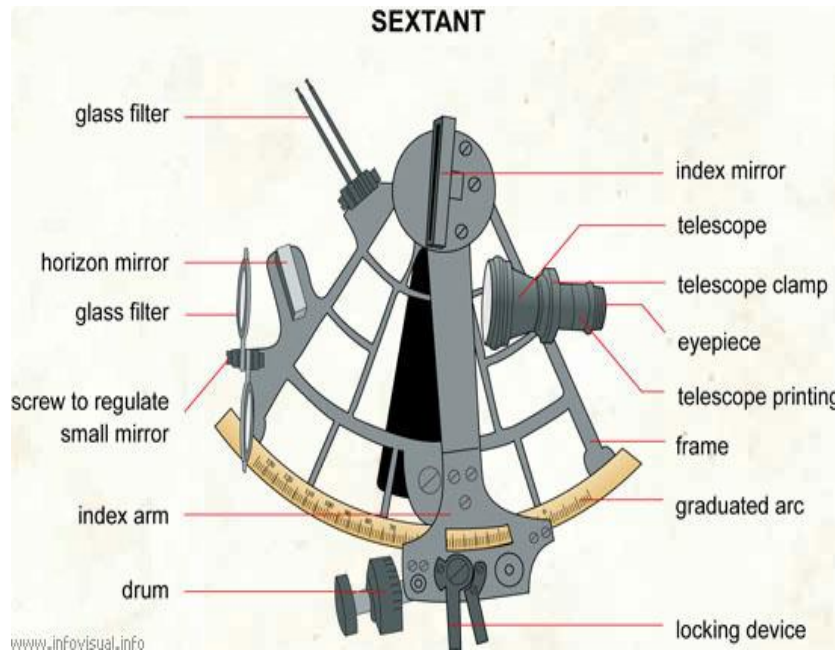


Fig. 1

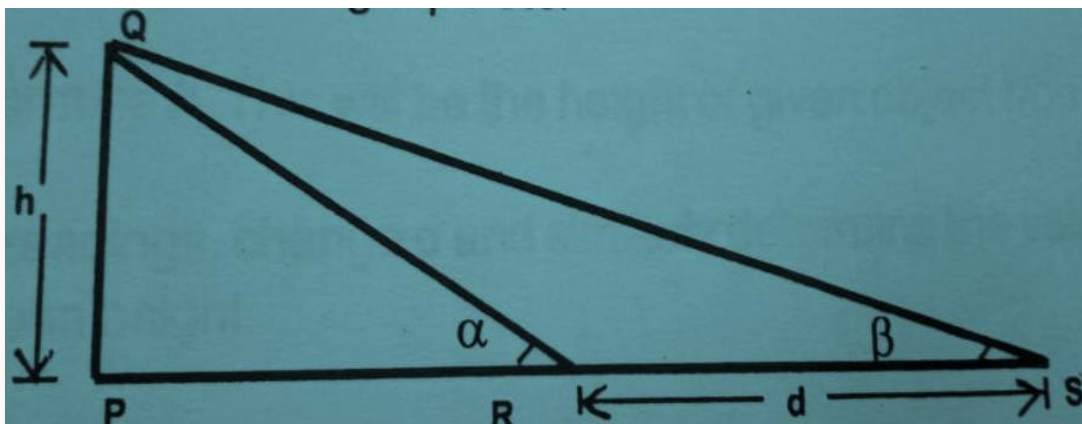


Fig. 2

THEORY: If H is height of given object α and β are the angles subtended by the object at two places R and S in the same horizontal plane then by geometry of figure, we can write.

$$\frac{h}{PR} = \tan \alpha$$

And $\frac{h}{(PR+d)} = \tan \beta$



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$$\text{Or } h \cot \alpha = (PR) \dots\dots\dots 1$$

$$\text{And } h \cot \beta = (PR + d) \dots\dots\dots 2$$

Subtracting (1) from (2), we get

$$D = h (\cot \beta - \cot \alpha) \dots\dots\dots 3$$

$$\text{Or } h = \frac{d}{(\cot \beta - \cot \alpha)}$$

PROCEDURE:

- 1 Determine the least count of circular and vernier scales.
- 2 Make a reference mark on the given object in level of your eyes
- 3 Move away from building by a considerable distance and select some place on the ground. Mark the position on their place, (say R) Now standing there point the telescope towards that reference mark. Direct image of marks will be visible through the transparent part of half silver mirror. Rotate the arm of sextant and get the reflected image of the reference mark by the mirror M. use micrometer screw so that these two images coincide. Note down this reading of vernier and main scale. It gives zero reading at that place.
- 4 Now rotate the arm so that rays from top of object fall on the mirror and after reflection reach the telescope. In this position you will see two images (a) the direct image of reference mark, (b) the doubly reflected image of the top of the object. Clamp the arm by tangent screw and adjust arm so that these two image completely coincide on the cross wires. Note down this reading. This gives the angular elevation of top with respect to the reference mark. Add or subtract from it the zero reading as the case may be it gives the angle α .
- 5 Now move away from the reference mark, say through a distance of 3 to 5 meter at point S. Again find the zero reading at this place. Repeat steps 3 and 4 and get the new angular elevation β at this place.
- 6 Find out the distance between two places of observation (R&S) by using a measuring tape.
- 7 Knowing α β and d determine h . This will be the height of given object from the reference mark.
- 8 To get the set of readings, change d and similarly determine the values of h , then determine the mean height.

OBSERVATION :

- 1 LEAST COUNT OF CIRCULAR SCALE:
- 2 LEAST COUNT OF VERNIER SCALE:



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OBSERVATION TABLE FOR α

S.No.	Zero reading when reference mark are coinciding			Reading whe top is coinciding with reference mark			$\alpha=(b-a)$	Mean α
	MS	CS	TOTAL	MS	CS	TOTAL		
1								
2								
3								
4								

OBSERVATION TABLE FOR β

S.No	Distance between two places in cm(d)	Zero reading when reference mark are coinciding			Reading whe top is coinciding with reference mark			$\beta =(b-a)$
		MS	CS	TOTAL	MS	CS	TOTAL	
1								
2								
3								
4								

CALCULATIONS:

$$h = \frac{d}{(\cot \beta - \cot \alpha)}$$

Using above formula the values of h can be determined from the measured values of d, α and β . Height of given object h=m



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RESULT: The height of given object above reference =meters

Total height of given object from ground = height of reference + height with respect to reference.

PRECAUTIONS:

1. Plane of index arm should be parallel to the moving arm and normal to the plane of the circular arc.
2. At the position of zero reading both mirrors M_1 and M_2 should be parallel to each other.
3. While taking reading the plane of the fixed arm and index arm should be kept vertical.
4. The telescope should be directed towards the centre of horizon glass M_2 .

EXPERIMENT-6

OBJECT: To determine the dispersive power of material of a prism with the help of spectrometer.

APPARATUS: A spectrometer, Mercury lamp in wooden box, Prism, spirit level, Magnifying glass etc.

Diagram:

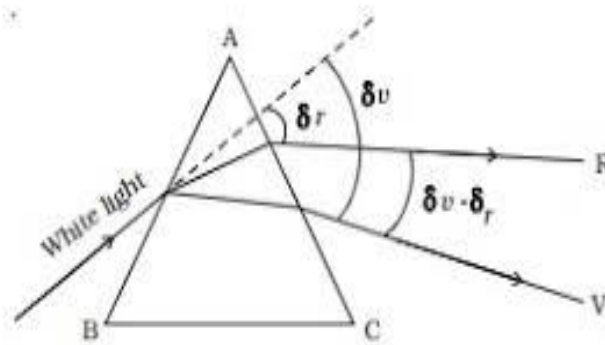


Fig. Dispersive power

FORMULA: The refractive index can be defined by the following formula

$$\mu = \frac{\sin(A + \delta_m)/2}{\sin A/2}$$

Where

μ = Refractive index

A = Prism angle in degree

δ_m = Angle of minimum deviation in degree

The dispersive power of material of prism is expressed by following formula

$$\omega = \frac{\mu_V - \mu_R}{\mu_Y - 1}$$

Where

ω = dispersive power

μ_V = refractive index for violet color

μ_R = refractive index for red color

μ_Y = refractive index for yellow color



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Method:

1. Illuminate the slit with the mercury light and adjust the telescope for perfect image of slit.
2. To measure the prism angle: First determine the least count of both the vernier scale of spectrometer. Put the prism on prism table so that its edge A is kept turned towards the collimator. Thus half of the light from collimator falls on faces AB and half on AC. Now turn the telescope in the horizontal place and locate the image of slit reflected from face AC. Note down the position of two vernier scale V_1 and V_2 . Now turn telescope towards the other side of prism facing AB. Focus it on the image of slit. Note down this position of two vernier scales V_1 and V_2 .
3. The difference between the two readings of same vernier taken on both side will give the angles through which the telescope has been rotated. Let this angle be $2a$. From the figure above it is clear that half angle will be the angle of prism a . For more accurate results repeat above procedure two to three times.
4. To determine the angle of minimum deviation δ_m : Put the prism on table in such a way that one of its reflecting surface AB lies normal to rays falling from collimator. Now rotate the prism through a very small angle to view the spectrum in the field of view of eyepiece.
5. Now rotate the prism in same direction and follows the image of red line through the telescope. Due to rotating of prism, angle of incidence increases, decreasing the angle of deviation. Slowly go on rotating the prism, the angle of deviation will go on diminishing. A stage will come when angle of deviation and therefore the image of line shall start turning back. This gives the position of minimum deviation. Note down this position of telescope on both the various scales V_1 and V_2 . Let this position be denoted by X.
6. Remove the prism and rotate the telescope after unclamping so that it directly face the collimator. Clamp the telescope any by adjusting the tangent screw being the image of slit cross wire. This direct reading gives the direction of incident rays. Note down the position be denoted by Y.
7. To get the angle of minimum deviation calculate difference between two reading of same vernier for two position of telescope i.e. $\delta_m = (x-y)$. Determine mean δ_m and calculate the refractive index.
8. Similarly determine the angle of minimum deviation for other lines (for violet, yellow lines). Similarly refractive index can be calculated for violet and yellow colors.
9. Knowing μ_v , μ_r and μ_y calculate dispersive power by using the formula:

$$\omega = \frac{\mu_v - \mu_r}{\mu_y - 1}$$



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OBSERVATION:

Least Count of vernier Scale =

Table for determination of A

S. NO.	Vernier Scale reading	When reflection take Place at the face AC			When reflection take place at the face AB			Difference of readings of the same vernier	Mean θ	a
		MS	VS	Total	MS	VS	Total			
1.	V ₁									
2.	V ₁									

Table for determination of δ_m :

S. NO.	Vernier Scale reading	Reading for minimum deviation position			Reading for direct slit position			Difference of readings of the same vernier	Mean θ
		MS	VS	Total	MS	VS	Total		
1.	V ₁								
	V ₂								
2.	V ₁								
	V ₂								
3.	V ₁								
	V ₂								

Calculation:

- i. Angle of prism A =
- ii. Angle of minimum deviation for Red color δ_{mr} =
- iii. Angle of minimum deviation for yellow color δ_{my} =
- iv. Angle of minimum deviation for violet color δ_{mv} =

Calculate refractive index μ_v, μ_R, μ_Y

$$\mu = \frac{\sin (A+\delta_m)/2}{\sin A/2}$$

Calculate dispersive power by using formula:

$$\omega = \frac{\mu_v - \mu_r}{\mu_Y - 1}$$



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RESULT: The dispersive power of the material of prism $\omega = \dots\dots\dots$

PRECAUTIONS:

1. The slit should be as narrow as possible but two knife edges of the slit should not touch each other.
2. The adjustments of the telescope, collimator and the prism table should be accurately done.
3. The height of the prism table should be so adjusted that the light must fall on the whole surface of the prism.
4. The prism table and the telescope must be clamped while taking readings.



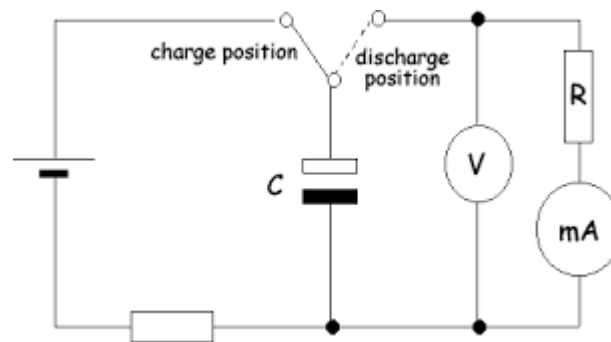
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EXPERIMENT-7

OBJECT: To study the charge and discharge of a condenser and hence determine the time constant.

APPARATUS: Network board RC-2 with regulated power supply, connecting cable, stop watch etc.

DIAGRAM:



FORMULA:

(a) The expression for charge voltage and current during charge and discharging of a condenser C are as following

For Charging

$$q = q_0 (1 - e^{-t/RC})$$

$$V = V_0 (1 - e^{-t/RC})$$

$$I = I_0 (1 - e^{-t/RC})$$

For Discharging

$$q = q_0 e^{-t/RC}$$

$$V = V_0 e^{-t/RC}$$

$$I = I_0 e^{-t/RC}$$

(b) The Time constant = RC

Where q_0 and q are maximum and instantaneous values of charge in coulomb, V_0 and V are maximum and instantaneous values of voltage in volt. I_0 and I are maximum and instantaneous values of current in amps. τ is time constant in seconds R is resistance in ohms C is capacitance in farad.

PROCEDURE:

- 1 Select the value of R and C on network Board such that theoretical value of time constant = RC is close to 100 sec. (Chose as possible)
- 2 Connect the circuit as shown in figure where S_1 and S_2 both are open and capacitor is fully charged.
- 3 Close switch S and immediately start a stop watch. This will start the charging of the capacitor.



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- 4 Reading in voltmeter will increase while current in millimeter will decrease. Record reading of volt meter and millimeter after 15 sec. till voltage reaches a maximum one becomes constant and current a minimum.
- 5 Now open switch and close switch and condenser will start discharging across R reading in volt meter will decrease whereas reading in millimeter will also start decreasing in opposite direction. Take their readings after every 15 sec.

OBSERVATION:

Theoretical value of time constant = RCsec.

$R =$ ohm, $C =$ fared

Time	(T sec.)	0	15	30	45	60	75	90	105	120	135	150
CHARGE	(V volts)											
	(I mA)											
DISCHARGE	(V volts)											
	(I mA)											

Note: keep on taking the readings until the voltage becomes constant (Both charging & discharging)

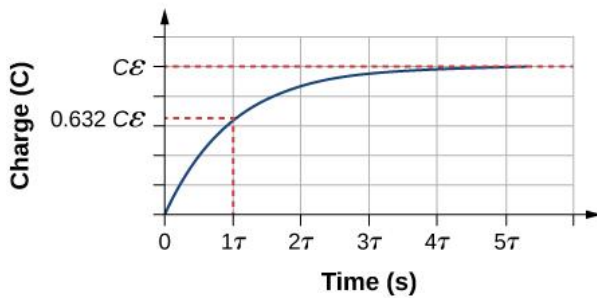
CALCULATION:

- (a) For charging of condenser :
Plot a graph in volt and time and other in current and time (These graphs will look like as bellow).



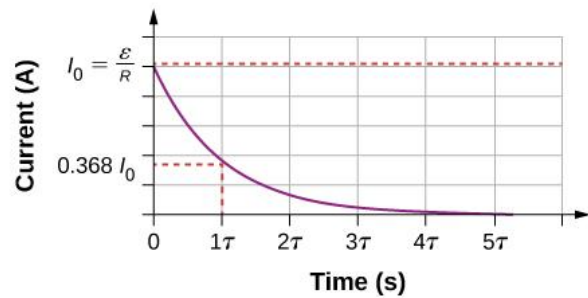
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Charge vs. Time Capacitor



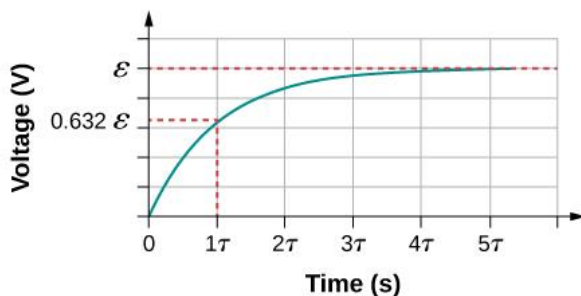
(a)

Current vs. Time Resistor



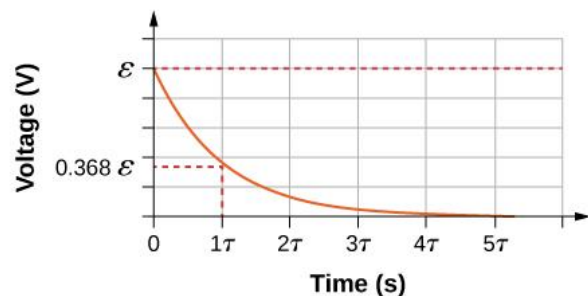
(b)

Voltage vs. Time Capacitor



(c)

Voltage vs. Time Resistor



(d)

If maximum voltage reached is V_0 then time constant is the time corresponding to the point where the voltage is $0.63 V_0$ compare it with theoretical value RC .

(b) For discharging of condenser

Plot one graph in voltage and time and other in current and time (These graphs will look like as above).

Find time constant which is the time corresponding to the point where voltage is $0.37 V_0$ compare it with theoretical value.

RESULT:

Analyze your observations and graphs carefully to report following:

- (1) The time constant for chargingsec. (Calculated)
- (2) The time constant for chargingsec. (Graphical)
- (3) The percentage error in time constant(Sec)
- (4) The time constant for dischargingsec. (Calculated)
- (5) The time constant for dischargingsec. (Graphical)
- (6) The percentage error in time constant(Sec)



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PRECAUTIONS:

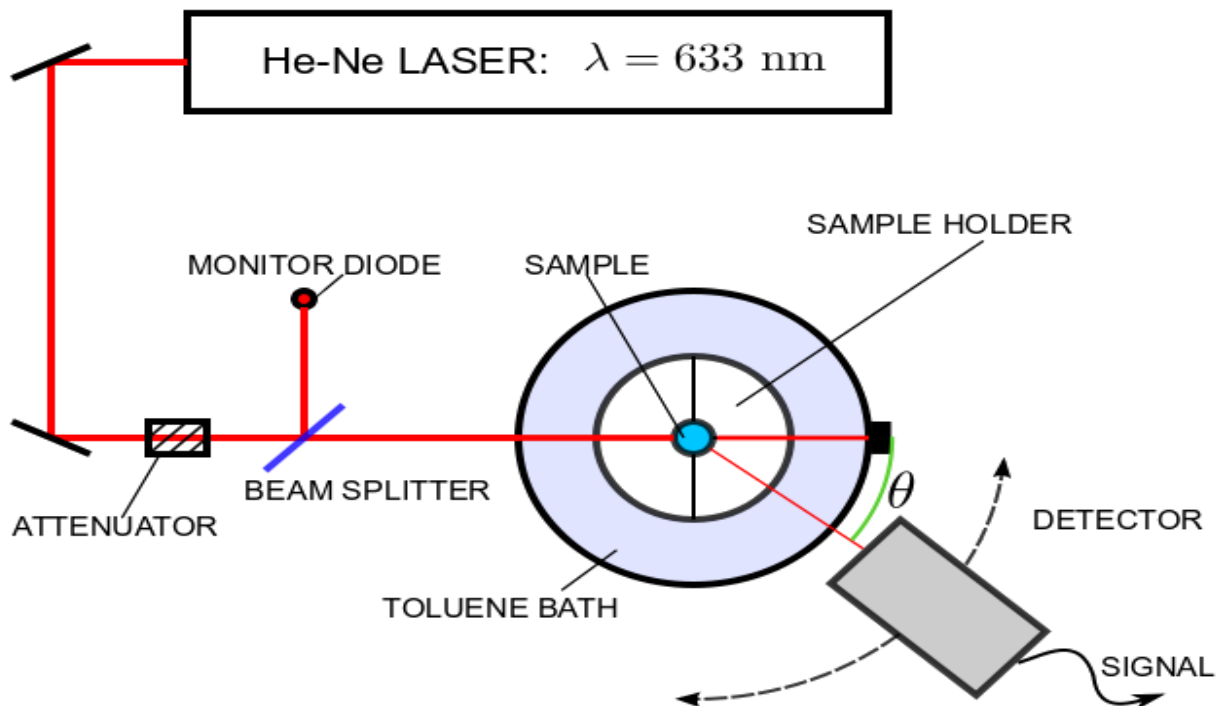
1. The value of resistance R and capacity C must be so chosen that the time constant of the circuit is large.
2. The pointer of the ammeter must be in the middle otherwise during discharge, it is likely to break on account of deflection in the opposite direction.
3. For the measurement of time, a timer or metronome or a sensitive stop watch must be used.
4. The charge on condenser also leaks through voltmeter. To reduce it, voltmeter of high resistance i.e. high range must be used. The source voltage must also be high.

EXPERIMENT-8

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

APPARATUS: Laser source with power supply (=63.28A), Spectrometer without collimator and telescope (with two holders one for laser source and another for laser detector), diffraction grating, etc.

Diagram:



THEORY AND FORMULA:

For light waves $v = \frac{c}{\lambda}$ ----- (1)

Differentiating, we get

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

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

Coherence time $\tau = \frac{\lambda^2}{c \Delta \lambda}$ ----- (2)

Hence coherence length $L = \tau c = \frac{\lambda^2}{\Delta \lambda}$

$L = Q\lambda = \text{Spectral purity} \times \text{wavelength}$



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PROCEDURE:

1. Put the laser source on a holder attached to the base spectrometer on one side of circular table and put detector on another holder attached to the base of spectrometer on other side of circular table, and connect this detector to digital ammeter.
2. The height of laser source and laser detector is kept same.
3. Place the diffraction grating on circular table and incident the laser rays perpendicularly on it as shown in Fig.
4. To calculate the angle of diffraction, adjust the laser source on first holder and clamp it and by slow-motion screw set the laser detector so that the reading of digital ammeter is maximum.
5. Note the reading on the vernier scales V_1 and V_2
6. Now bring the laser detector on the first order spectrum, on either side of the normal and note the reading of the two scales V_1 and V_2 when digital ammeter shows maximum current.
7. The difference between the either side readings gives double the angle of diffraction.
8. Repeat the above procedure for higher order of spectrum.

OBSERVATION TABLE:

S.N O.	Order of spectrum	Vernier Scale Readin g	Spectrum to the left of the direct image			Spectrum to the right of the direct image			$2\theta =$ a - b	Mean θ
			M.S.	V.S.	Total reading (a)	M.S.	V.S.	Total reading (b)		
1.	First order	V_1								
		V_2								
2.	Second order	V_1								
		V_2								
3.	Third order	V_1								
		V_2								

(A) Least count:

Smallest main scale division(x)..... degrees.

Total no. of division on vernier scale (n).....

$$\therefore \text{Least count} = \frac{x}{n} = \dots\dots\dots$$



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(B) The no. of lines ruled per inch on the grating $N = \dots\dots\dots$

$$\therefore \text{Grating element } (a + b) = \frac{2.54}{N} = \dots\dots\dots \text{cm}$$

(C) The wavelength $\lambda = \frac{(a+b) \sin \theta}{n}$

Put $n = 1, 2, 3, \dots\dots$ for first order, second order third order spectrum.....

Then mean wavelength

$$\lambda = \frac{\lambda_1 + \lambda_2 + \lambda_3}{3} = \dots\dots A$$

(D) Calculation of coherence length:

$$\Delta \lambda = \lambda_1 - \lambda_2, \quad \Delta \lambda = \lambda_2 - \lambda_3, \quad \Delta \lambda = \lambda_1 - \lambda_3 \text{ etc.}$$

$$\therefore \text{Coherence length } (L_1) = \frac{\lambda_1^2}{\Delta \lambda} = \frac{\lambda_1^2}{\lambda_1 - \lambda_2}$$

$$L_2 = \frac{\lambda_2^2}{\Delta \lambda} = \frac{\lambda_2^2}{\lambda_1 - \lambda_3}, \quad L_3 = \frac{\lambda_3^2}{\Delta \lambda} = \frac{\lambda_3^2}{\lambda_1 - \lambda_3}$$

$$\therefore \text{Coherence length } L = \frac{L_1 + L_2 + L_3}{3}$$

(E) Coherence time:

$$\tau = \frac{L}{c}$$

RESULT:

The wavelength of laser light (λ) = $\dots\dots\dots \text{\AA}$

Coherence length of laser (L) = $\dots\dots\dots \text{\AA}$

Coherence time $\tau = \dots\dots\dots \text{sec.}$

PRECAUTIONS:

1. Clamping of laser detector and table must be proper.
2. Reading of both the vernier scales at both windows is essential.
3. Grating should be cleaned properly.
4. Laser beam is very injurious for eyes so do not see it directly.

EXPERIMENT-9

Object: To measure the numerical aperture of an optical fiber.

Apparatus: Laser source, fiber optic chuck, optical fiber, screen, graph paper, etc.

Diagram:

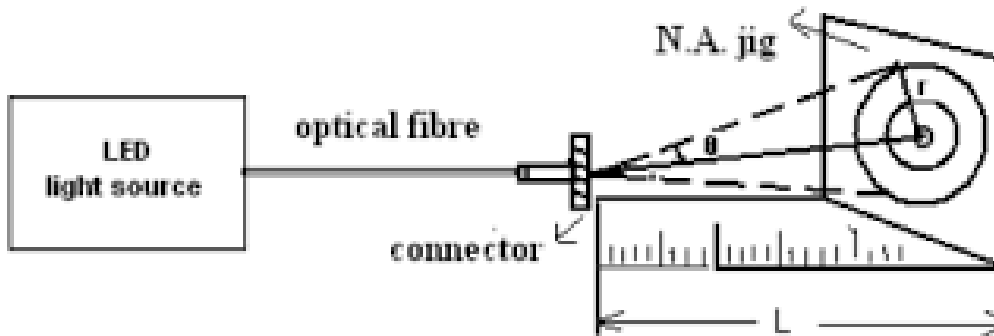


Figure 1 Arrangement for N.A. measurement

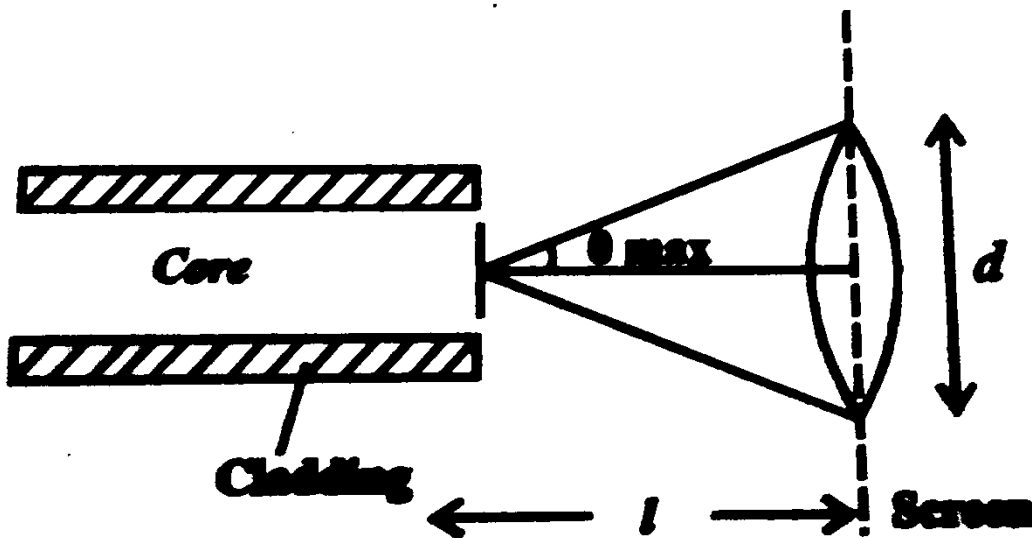


Fig.2

Theory and formula:

Numerical aperture is a measure of how much light can be collected by an optical fiber. It is related to acceptance angle, which indicates the size of cone of light that can be accepted by fiber. The numerical aperture is defined as

$$NA = n_0 \sin \theta_{\max} \quad (1)$$

Where n_0 is the refractive index of the incidence medium and θ_{\max} is the maximum angle at which optical ray can enter and propagate in the fiber.



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Thus $NA = \sin \theta_{max}$ for air as incidence medium.

For step index fiber the NA is given by

$$NA = \sqrt{n_1^2 - n_2^2} \quad (2)$$

Where n_1 is refractive index of core and n_2 is refractive index of cladding.

From the above diagram

$$\sin \theta_{max} = \frac{d}{\sqrt{4l^2 + d^2}} \quad (3)$$

$$NA = \frac{d}{\sqrt{4l^2 + d^2}} \quad (4)$$

Where d = Diameter of the circle on screen

l = Distance between output end of optical fiber and screen

PROCEDURE:

- 1 Mount both the ends of the optical fiber on the fiber optic chuck.
- 2 Couple the light from the laser source onto one of the fiber end.
- 3 Place the screen at some distance from the output end (end other than at which light is coupled) of the fiber such that it is perpendicular to the axis of the fiber.
- 4 Now move the screen towards or away the output ends of the optical fiber, such that a circular spot is formed on the screen.
- 5 Measure the distance between the output end of optical fiber and screen. Let it be l .
- 6 The diameter of the circle on screen can be measured by putting a graph paper on the screen.
- 7 Repeat the above procedure for different values of l and d and record observation in table. Calculate the average value of numerical aperture.

Observation table:

S. No.	Distance of screen from chuck (l)	Diameter of central spot (along x-axis)			Diameter of central spot (along Y-axis)			Average $d = \frac{d_1 + d_2}{2}$
		X_1	X_2	$X_2 - X_1 = d_1$	Y_1	Y_2	$Y_2 - Y_1 = d_2$	
1								
2								
10								



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Calculation:

NA and maximum angle of acceptance are calculated using the formula:

$$NA = \frac{d}{\sqrt{4l^2 + d^2}}$$

The maximum angle of acceptance is $\theta_m = \sin^{-1}(NA)$

RESULT:

- (1) Numerical Aperture (NA) of the optical fiber is
- (2) The maximum angle of acceptance is.....

PRECAUTIONS:

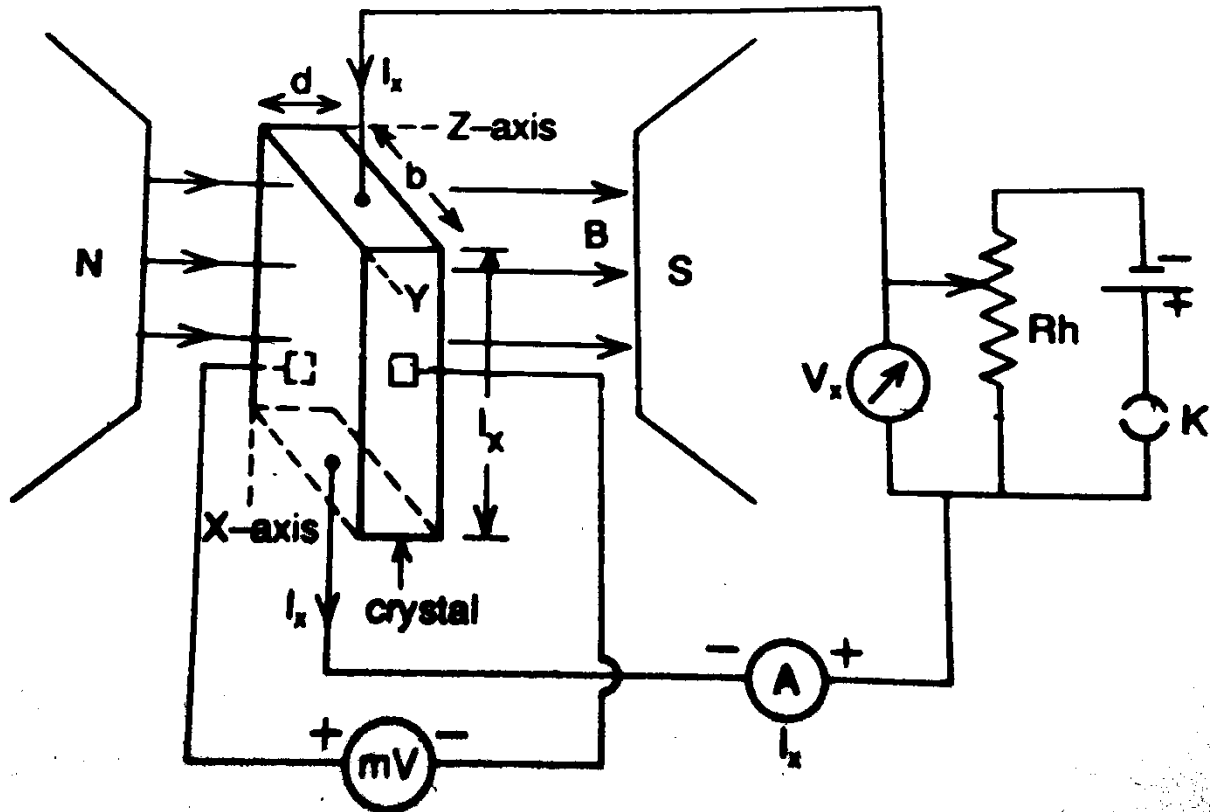
1. Optical source should be properly aligned with the cable.
2. Distance of the launch point from cable should be properly selected to ensure that maximum amount of optical power is transferred to the cable.
3. The optical fibre provided should be handled carefully so as to prevent cracks.

EXPERIMENT-10

OBJECT: To study Hall Effect and determine Hall voltage and Hall coefficient.

APPERATUS: Electromagnet, Gauss meter, Mill voltmeter, Hall Effect experimental set up, hall probe containing semiconductor sample.

FIGURE:



THEORY & FORMULA:

If a current carrying conductor is placed in transverse magnetic field, an electric field is generated inside the conductor in a direction perpendicular to both the current and the magnetic field. This phenomenon is called Hall Effect and electric field so generated is called Hall field. A rectangular specimen of a semiconductor of width b and thickness t is placed between poles of an electromagnet such that magnetic field is applied along z direction. The hall voltage V_H can be measured with the help of two probes placed at the centre of top and bottom surface of sample. To determine Hall coefficient following formula can be used

$$R_H = \frac{V_H t}{I_x B_z} \quad \text{in m}^3/\text{coloumb.}$$

Where V_H = Hall voltage in volts

B_z = Magnetic field applied along z axis in weber / m^2

I_x = Current along x axis in amperes

t = thickness of sample in meters



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PROCEDURE:

1. Place the specimen in the magnetic field and make connections as shown in diagram.
2. Allow some current I_x with the help of rheostat to flow through the semiconductor specimen along x axis. Measure hall voltage V_H by Milivoltmeter and V_x by voltmeter.
3. Change value of I_x and note corresponding change in V_H and V_x . Then plot a graph between V_H and I_x . This graph will be a straight line. The slope of this graph will provide the ratio V_H/I_x .
4. Measure magnetic field B with gauss meter or flux meter and find the actual field $B_z = \mu B$.

OBSERVATION:

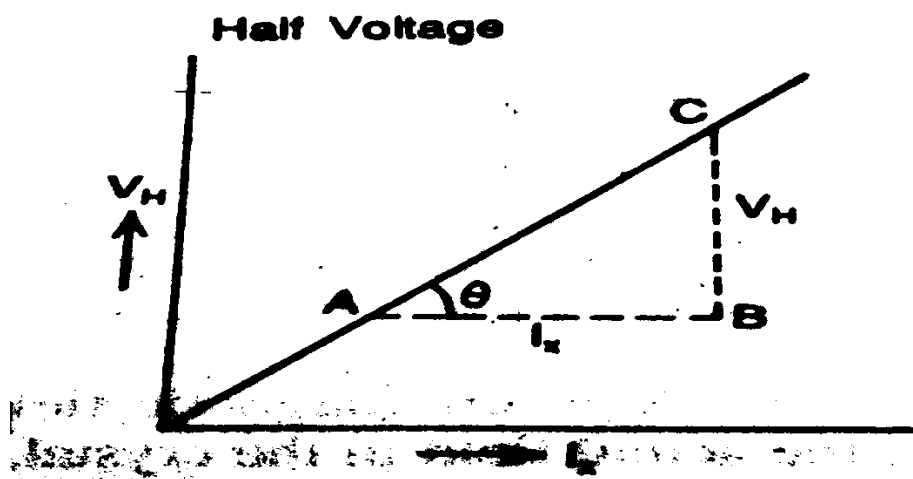
1. Permeability of the specimen $\mu =$
2. Magnetic field $B =$ Weber/m²
3. Thickness of the specimen $t =$ meters

OBSERVATION TABLE:

S. No.	Current I_x in amperes	Applied voltage V_x in volts	Hall voltage V_H in volts
1			
2			
3			
4			
5			

CALCULATIONS:

A graph is plotted between V_H and I_x . The slope of this graph will provide the ratio V_H/I_x .





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The Hall coefficient can be calculated by using this slope and the formula

$$R_H = \frac{V_H t}{I_x B_z} \quad \text{in m}^3/\text{coulomb.}$$

RESULT:

Hall coefficient $R_H =$ _____ $\text{m}^3/\text{coulomb}$

PRECAUTIONS:

1. Hall voltage developed is a small quantity and should be measured with accuracy.
2. Current through the specimen shall be in permissible limits.
3. Do not disturb the specimen once fixed to measure the parameters accurately.