POORNIMA INSTITUTE OF ENGINEERING & TECHNOLOGY, JAIPUR

DEPARTMENT OF FIRST YEAR

Lab Manual and Student Guide

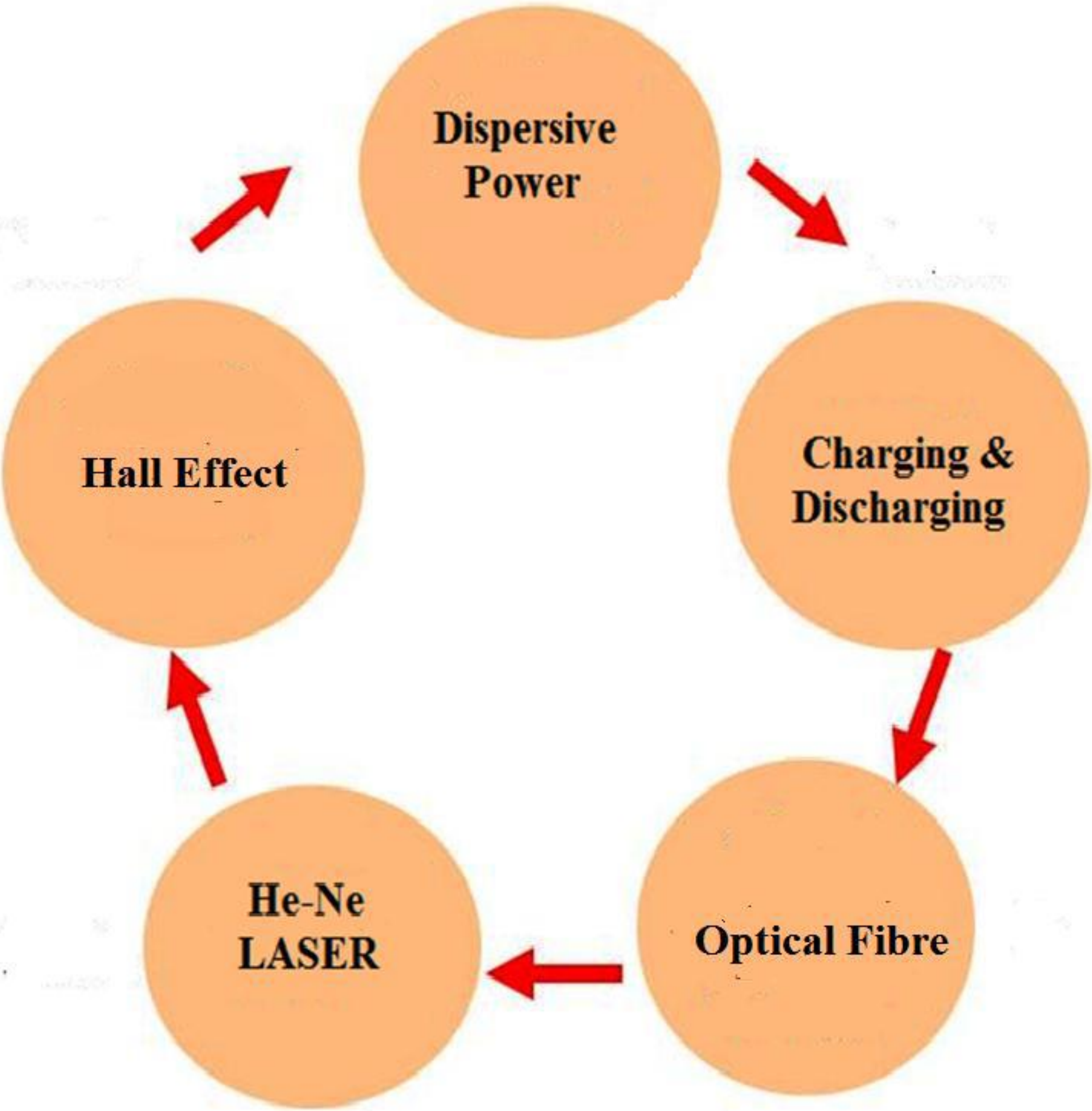
ENGINEERING PHYSICS LAB

1/2FY2-20

II Rotor

POORNIMA
INSTITUTE OF ENGINEERING & TECHNOLOGY

Engineering Physics Lab (1FY2-20/2FY2-20)
ROTOR-II



Distribution of lab hours

Attendance	05 minutes
Explanation of the concept	15 minutes
Explanation of experiment	15 minutes
Performance of experiment	70 minutes
Evaluation & Viva	15 minutes
Total	**120 minute**

PHYSICAL CONSTANTS

Planck constant h:	$6.6260755 \times 10^{-34}$ J·s
Boltzmann constant k_B:	1.380658×10^{-23} J/K (= $8.617385 \cdot 10^{-5}$ eV/K)
Elementary charge e:	$1.60217733 \times 10^{-19}$ C
Avogadro number NA:	6.0221367×10^{23} particles/mol
Speed of light c:	2.99792458×10^{8} m/s
Electron rest mass m_e:	$9.1093897 \times 10^{-31}$ kg
Proton rest mass m_p:	$1.6726231 \times 10^{-27}$ kg
Neutron rest mass m_n:	$1.6749286 \times 10^{-27}$ kg
Acceleration due to gravity g:	9.80665 m/s^2

Experiments

Experiment No.: 6

Object: To determine the dispersive power of the material of a prism by spectrometer.

Apparatus: Spectrometer, Prism, Spirit level, Reading lens and Mercury lamps.

Formula: The dispersive power of the material of a prism is given by-

$$w = \frac{\theta}{\delta_y} = \frac{\delta_v - \delta_r}{\delta_y} = \frac{\mu_v - \mu_r}{\mu_y - 1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where

Θ = Angle between two extreme colors

δv =Angle of minimum deviation for extreme violet color.

δr =Angle of minimum deviation for extreme red color.

δy =Angle of minimum deviation for mean yellow color.

μ_v = Refractive index of the material of a prism for extreme violet color.

μ_r = Refractive index of the material of a prism for extreme Red color.

μ_y = Refractive index of the material of a prism for yellow mean color.

Refractive index is given by

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

Where

A = Angle of prism.
δm = Angle of minimum deviation.

Diagram:

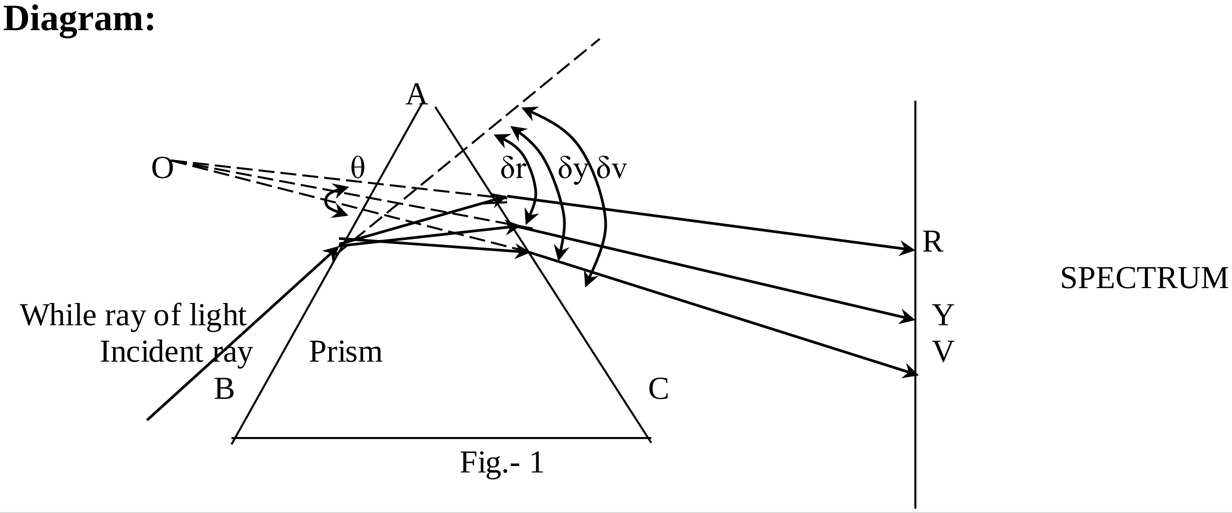


Fig.- 1

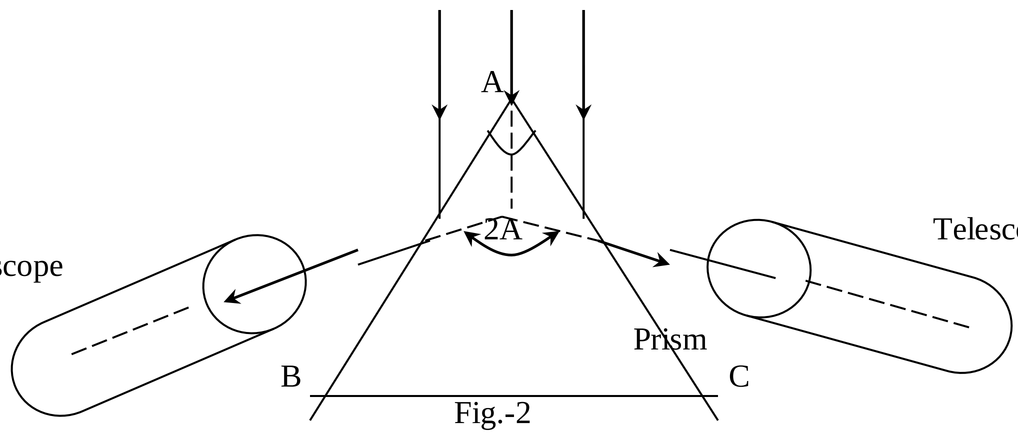


Fig.-2

Procedure:

To obtain pure spectrum by spectrometer the following adjustment must be made-

- The Prism table is leveled with the help of spirit level.
- The slit of collimator should be made narrow, vertical and symmetrical on both sides.
- ***Adjustment of Collimator:***

(i) It consists of a tube mounted horizontally on the arm of spectrometer.

(ii) The vertical slit consist of two sharp edges, which of them one is fixed and other can be moved parallel to it with the help of a screw.

(iii) Finally keep the collimator slit near the window of source.

- ***Adjustment of Prism table:***

(i) The prism table has three leveling screws attached to its base.

(ii) The height of prism table can be adjustment by a clamping screw.

(iii) Now the position of table can be read by verniers moving on the circular scales.

- ***Adjustment of Telescope:***

(i) The telescope is turned towards an illuminated source of light.

(ii) Now see through the eye piece and then adjust the distance between object and eye piece and get a well-defined image of object at the cross wires.

(iii) Thus in first arrangement, the telescope is focused for parallel rays while in second, the collimator produces a beam of parallel rays.

- ***Determination of the Angle of Prism:***

(i) Place the prism on prism table with its refracting edge at the centre and ground face perpendicular to the collimator axis as shown in fig.- 2.

(ii) The reflected light from each face of prism gives on image of the slit let for this see the reflected light from face on the right side.

(iii) Similarly get an image of slit on the left side formed by reflection of light from the other face of the prism and note the both readings.

(iv) The difference of these two angles will double (i.e. 2A) of prism angle.

(v) Hence repeat the process several times and find the mean value of A.

- ***Measurement of Angle of Minimum Deviation:***

(i) Place the prism symmetrically at the centre of prism table with it ground face away form collimator.

(ii) Set the telescope at about 45 to axis of collimator. Now rotate prism table towards left or right through a very small angle to make a small angle to normal.

(iii) Now, rotating the prism table, spectrum will also rotate. Move the telescope also to keep the spectrum in the field of view. A stage comes when the spectrum just starts returning back. This position is minimum deviation position. At this orders VIBGYOR.

(iv) Now turn the telescope and set it cross wire on red line of spectrum. Now set the cross wire on this line and note the reading of both the verniers. Similarly set the cross wire on different colours line i.e. Yellow, Violet respectively and note the readings.

- ***Direct Image:***

To obtain the direct image, remove the prism from the prism table and turn telescope to obtain direct image. Set the telescope in front of collimator as the cross wire coincide with image of slit. Note the readings of both verniers.

Observations and Observation Table:

One division of M.S. x = ………………………

No. of division of V.S. n = ………………………

Least count of V.S. x/n = …………………….

(a) Table for angle of prism (A)

<table>
<tr><th rowspan="2">S. No.</th><th rowspan="2">Vernier Scale</th><th colspan="4">Reflection from face AB</th><th colspan="4">Reflection From face AC</th><th rowspan="2">Difference 2A= (P-Q)</th><th rowspan="2">Mean value 2A</th></tr>
<tr><th>MSR</th><th>VD</th><th>VSR</th><th>TR (P)</th><th>MSR</th><th>VD</th><th>VSR</th><th>TR (Q)</th></tr>
<tr><td rowspan="2">1.</td><td>V1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>V2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

(b) Table for angle of Minimum Deviation (δm)

<table>
<tr><th rowspan="2">S. No.</th><th rowspan="2">Colours</th><th rowspan="2">Scale</th><th colspan="3">Reading in Minimum Deviation Image</th><th colspan="3">Reading for Direct Image</th><th rowspan="2">δm= a-b</th><th rowspan="2">Mean δm</th></tr>
<tr><th>MSR</th><th>VD</th><th>TR (a)</th><th>MSR</th><th>VD</th><th>TR (b)</th></tr>
<tr><td rowspan="2">1.</td><td rowspan="2">Red</td><td>V1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td rowspan="2"></td></tr>
<tr><td>V2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">2.</td><td rowspan="2">Yellow</td><td>V1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td rowspan="2"></td></tr>
<tr><td>V2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">3.</td><td rowspan="2">Violet</td><td>V1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td rowspan="2"></td></tr>
<tr><td>V2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Calculations:

(i) Angle of prism = …………………. Degree.

(ii) The refractive index for different colours is given by

$$\mu_v = \frac{\sin\left(\frac{A+\delta_v}{2}\right)}{\sin\frac{A}{2}} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$\mu_r = \frac{\sin\left(\frac{A+\delta_r}{2}\right)}{\sin\frac{A}{2}} = \ldots\ldots\ldots\ldots\ldots\ldots$$

$$\mu_y = \frac{\sin\left(\frac{A+\delta_y}{2}\right)}{\sin\frac{A}{2}} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

(iii) Dispersive power of prism's material

$$w = \frac{\mu_v - \mu_r}{\mu_y - 1} = \ldots\ldots\ldots\ldots \text{OR } w = \ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

(iv) Standard dispersive power of crown glass $w_{st} = 0.015$

$$\% \text{ Error} = \frac{w_{st} - w_{Observed}}{w_{st}} \times 100 = \ldots\ldots\%$$

Result:

The dispersive power of prism's material is =………

Percentage error = ………. %

Precautions:

1. The telescope should be focused for infinity and the collimator should be adjusted to give a paralleled beam of light.
2. The axis of telescope and collimator, and the plane of prism table should be horizontal.
3. The slit should be as narrow as possible.
4. The prism table should be leveled as that the maximum light must fall on the entire surface of prism.
5. At the time of observation, the telescope and the prism table should be clamped.
6. The telescope should be used on both verniers to note the readings.
7. Before observation, clean to prism and lens.
8. The circular scale table should be kept fixed during experiment.

Viva-Voce:

Q. 1. What is meant by dispersion?

Ans. When a white light's ray passes, it is separated in to rays of its constituent colours. This phenomenon is known as dispersion.

Q. 2. What is normal dispersion?

Ans. If the reflective index μ increasing with the decreasing order of wavelengths, then the dispersion is said to be normal.

Q. 3. What is anomalous dispersion?

Ans. If the refractive index is higher for longer wavelengths, then the dispersion is said to be anomalous.

Q. 4. What is angle of deviation?

Ans. The angle between the incident ray and the emergent of light is known as the angle of deviation?

Q. 5. What is the use of collimator in the spectrometer?

Ans. The collimator makes the light rays coming from the light source parallel to each other.

Q. 6. What is the type of your mercury lamp?

Ans. Mercury lamp is a hot cathode positive column type white light source.

Q. 7. What is the angle of prism?

Ans. The angle between the refracting surface of the prism is called angle of prism.

Q. 8. Which prism out of crown and flint glasses is used for better dispersion?

Ans. Flint glass, because $\omega f > \omega c$.

Q. 9. What do you mean by angular dispersion?

Ans. Angular dispersion of any two colours (wavelengths) is the difference between the deviations of those wavelengths (colours).

Q.10. Why is Huygens's eyepiece not used in the telescope or spectrometer?

Ans. Because it does not contain cross wire for talking observations.

Q. 11. Can any other device also disperse the light?

Ans. Yes, the diffraction gratings also disperse white light.

Q. 12. Can you determine the dispersive power of a prism using sodium light?

Ans. No, this is not possible because sodium light is quasi-monochromatic light and emits onl two yellow lines.

Q. 13. On what factors does it depend?

Ans. It depends on the nature of material and on the wavelength for which it is determine.

Q. 14. What is the best source of light for determine dispersive power of prism?

Ans. Neon lamp. Because it emits the light in all regions of the visible spectrum.

Q. 15. How does a ray pass through a prism at minimum deviation?

Ans. Inside the prism the ray passes parallel to the base of the prism.

Q. 16. What are the names of the seven colours of sunlight spectrum?

Ans. The seven colours are- Violet, Indigo, Blue, Green, Yellow, Orange and Red (VIBGYOR).

Q. 17. Does the deviation depend on the angle of prism?

Ans. Yes, greater the angle of prism more is the deviation.

Q. 18. Does the deviation depends on the colours?

Ans. Yes, the deviation is less for red then for violet light.

Q. 19. What is eye-piece?

Ans. Eye-piece is a magnifier designed to give more perfect image then obtained by a single lens.

Q. 20. Does the deviation depends on the length of prism's base?

Ans. No, it is independent of the length of base.

Q. 21. Will the angle of minimum deviation change, if the prism is immersed in water.

Ans. Yes, the refractive index of glass in water is less then in air. Hence the angle of minimum deviation is less.

Q. 22. What is the working temperature of a mercury lamp?

Ans. The working temp. of mercury lamp is a approximately 6000ºC.

Q. 23. What is the construction of Ramsden's eye-piece?

Ans. Ramsden's eyepiece consists of two Plano concur lenses each of focal length f separated by a distance equal to $2f/3$.

Q. 24. How does refractive index μ vary with wavelength?

Ans. Higher is the wavelength, smaller is the refractive index.

Q. 25. Do the light rays of different colours travel with the same velocity in air?

Ans. In air, the light rays of different colours travel with the same velocity.

Q. 26. What is normal spectrum?

Ans. When the rate of change of the deviation with wavelength of light ($d\delta/d\lambda$) is same for all parts of spectrum, then the spectrum is said to be normal.

Experiment No.: 7

Object: To study the charging and discharging of a condenser and hence determine the same constant (both) current and voltage graphs are to be plotted.

Apparatus: Connecting Leads, D.C. Source Battery, Resistance of various values R_1, R_2, R_3, Condensers of different capacities (C_1, C_2, C_3), Millimeter, Voltmeter keys, Stopwatch etc.

Theory & Formula:

i) The voltage charge across condenser during charging is given by:

$$V_c(t) = V_o\, e^{-t/RC} \text{ ------------------ } (1)$$

$$Q_c = Q_o\,[1- e^{-t/RC}]$$

ii) The voltage across resistance during charging is given by:

$$V_R = V_o e^{-t/RC} \text{ --------------------- } (2)$$

iii) The current in the circuit at any time t is given by:

$$I(t) = V_R/R = V_o/R\, e^{-t/RC} = I_o\, e^{-t/RC} \text{ ------------------- } (3)$$

iv) The voltage Vc across condenser during discharging is given by:

$$V_c = V_o\, e^{-t/RC} \text{ ------------------- } (4)$$

v) The voltage VR across resistance during discharging is given by:

$$V_R = V_o\, e^{-t/RC} \text{ ------------------- } (5)$$

vi) The current (t) in the circuit at any time t is given by:

$$I(t) = -V_R/R = -V_o/R\, e^{-t/RC} = -I_o\, e^{-t/RC} \text{ ---------------- } (6)$$

vii) Time constant (t) in the circuit at any time t is given by:

(a) During charging at t = RC = T

$$V_c(t) = V_o[1-e^{-t/t}\,] = V_o[1-e^{-1}] = V_o(1-1/e)$$

$V_c(t) = V_o[1-1/2.718] = 0.63V_o$ -------------------- (7)

(b) During discharging at $t = RC = T$

$V_c = V_o e^{-t/RC} = V_o e^{-1} = V_o.1/2.718 = 0.37V_o$ ----------------- (8)

(c) Using equ. (3) We have

$I(t_2)/I(t_1) = e$

$Log_e I(t_2) - Log_e I(t_1) = -(t_2-t_1/T)$

$T = (t_2-t_1)/Log_e I(t_1) - Log_e I(t_2)$

$T = (t_2-t_1)/2.303\ [Log_{10}\ I(t_1) - Log_{10}\ I(t_2)]$ ----------------------- (9)

Where

Q = Charge on condenser in coulomb.

$V_c(t)$ = Voltage across condenser in volt.

$I(t)$ = Current in the circuit in ampere.

R = Resistance in the circuit in ohm (Ω).

C = Capacity of a condenser in farad.

Q_o, V_o, I_o = Maximum charge, Voltage and Current respectively.

$t = RC = T$ = time constant in second.

Circuit diagram:

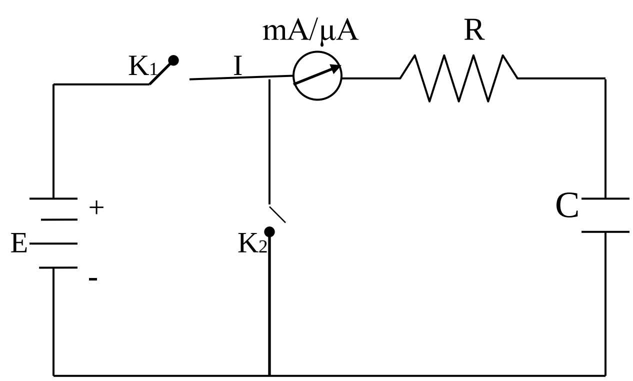


Fig.- 1 Circuit Diagram

Where

E = EMF of the battery; K1, K2 = One way key

R = Resistance in circuit; C = Condenser in circuit

RC = Circuit; I = Current in circuit

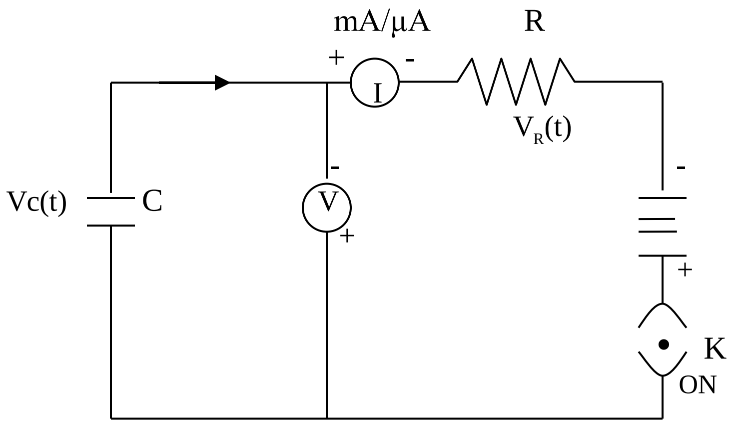


Fig.- 2 Charging (taking Voltage across capacitor)

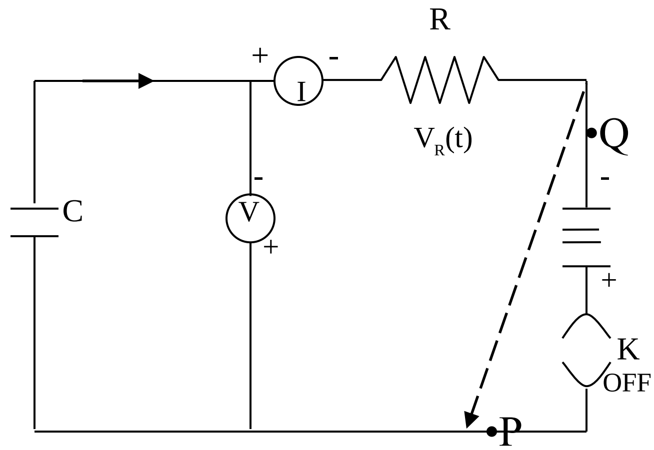


Fig.- 3 Discharging (taking Voltage across capacitor)

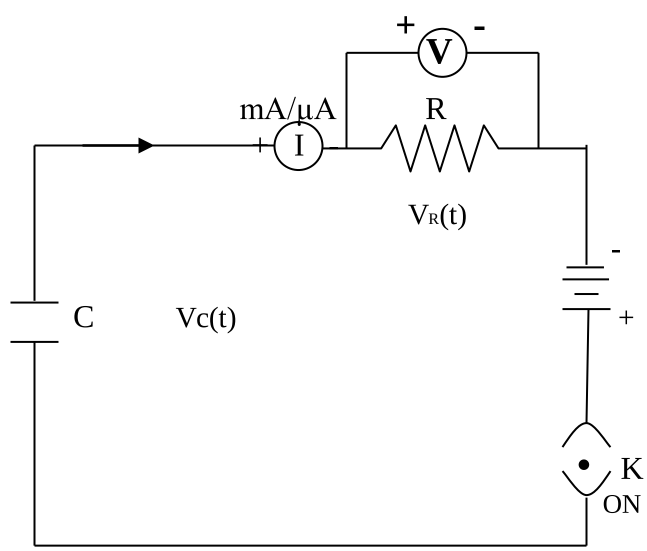


Fig.- 4 Charging (taking Voltage across resistor)

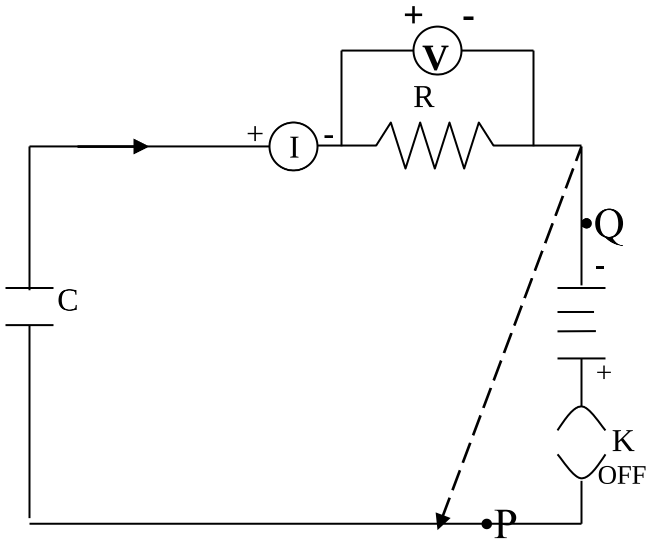


Fig.- 5 Discharging (taking Voltage across capacitor)

Procedure:

1. Make connections as shown in figure- 1.
2. The value of resistance R and Condenser c are so selected that the time constant RC is large (Approximately RC= 50 or 100 Seconds).
3. When key K is pressed/ON, current in the circuit gets started. Condenser starts charging. The stop watch is also started simultaneously to note time.
4. The reading of the Voltmeter (Vc) is noted after every 20/25 seconds till it becomes almost constant. [Vc(t)*t]
5. The condenser can be discharging by taking plug outside the key K and connect Q to P. ie making short circuit and the step 4 is repeated. ie Vc(t) is noted for discharging of condenser.
6. Now repeat the step 3 and 4 and note the readings in ammeter (multemeter) instead of voltmeter for same set of time. This given current I(t) during charging of condenser. [I(t) Vrs t]. This can also be achieved by formula I(t) = Vc(t)/R.
7. Now repeated step 5 and note readings on ammeter for the same set of time. This given current during discharging of condenser.
8. Steps 3 and 4 can be repeated if we want to take voltage, across resistance R [V_R(t)] during charging time and step 5 can be repeated for discharging of a condenser and various readings can be taken.

Observation:

Least count of a Voltmeter = x/n = …………… = ………. Volt.

Values of V_0 = ……….. Volt

R = ………... ohm

C = ……….. Farad

(A) Table for values of voltage across R and current across C in time t [Table for values of $V_R(t)$ and I(t) in time 't'.] :

S. No.	Charging $V_R(t)$ V/s t				Discharging $V_R(t)$ V/s t			
	Time t (Sec.)	$V_R(t)$ {Volts}	$I(t)=V_R(t)/R$ (Amp.)	Log_{10} I(t)	Time t (Sec.)	$V_R(t)$ {Volts}	$I(t)=V_R(t)/R$ (Amp.)	Log_{10} I(t)
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

Calculation:

(i) Plot a graph between Vc(t) versus t while charging and discharging of a condenser. Determine the maximum voltage Vo (where readings got stable). Calculate Vc(t) = 0.63 Vo and Vc(t) = 0.37 Vo from the graph of charging of condenser find the time corresponding to this value 0.63 Vo.

(ii) Similarly the time corresponding to 0.37 Vo on the graph of discharging of condenser must be obtained. This should also be equal to time constant T= RC, as shown fig.- 6.

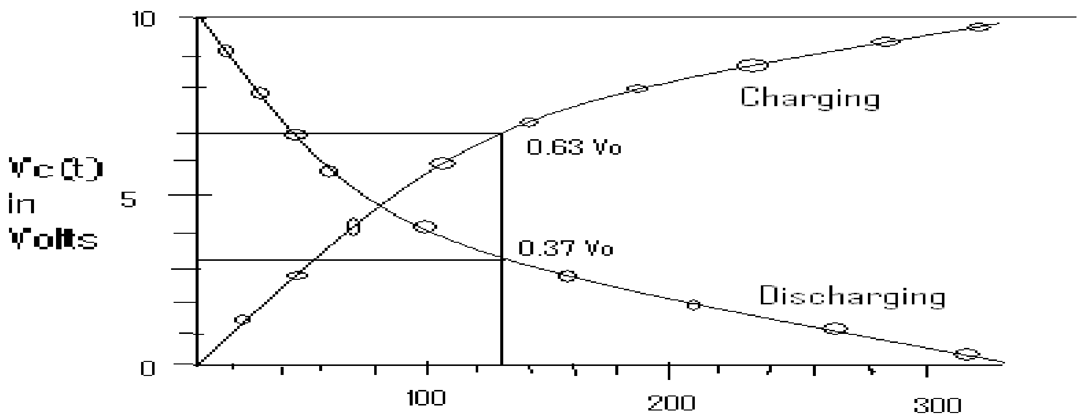


Fig.- 6 Variation in voltage for charging and discharging of Condenser.

(iii) Now plot a graph I and t. From I(t)-t graph for charging of condenser time corresponding to 0.37 Io (maximum current) should be noted. Further for I(t)-t graph for discharging of condenser the time corresponding to 0.63 Io should be noted. Both these timing should match the theoretical value of time constant Tc= RC. As shown in fig.- 7.

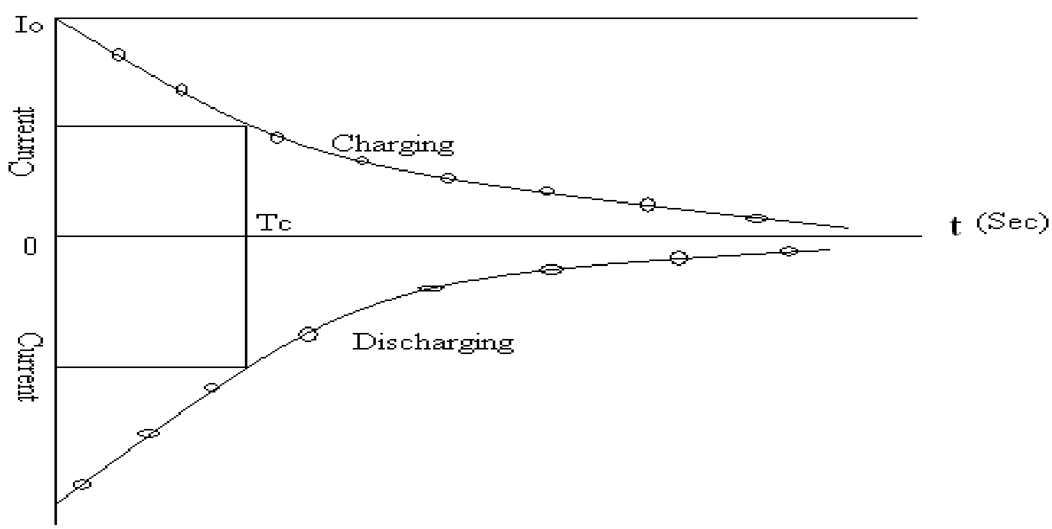


Fig.- 7 Variation in current for charging and discharging of a Condenser.

(iv) Lastly plot a graph Log_{10} I(t) and t and the time corresponding to Log_{10} I(t1) and Log_{10} I(t_2) ie t_1 and t_2 should be noted as shown in fig.- 8.

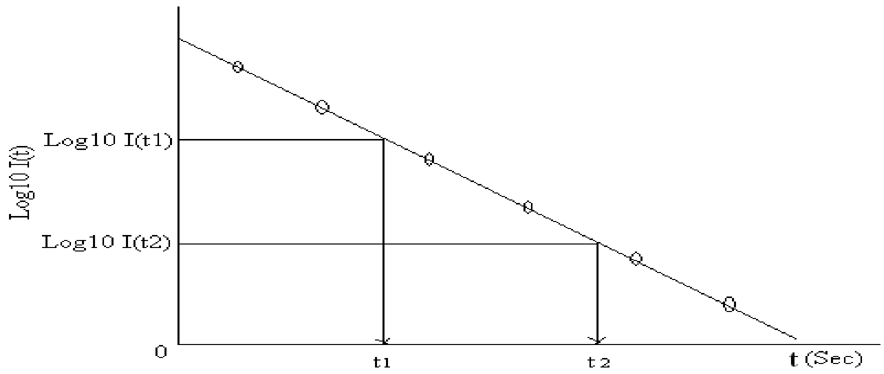


Fig.-8 Variation in Log_{10} I(t) and time (t).

Time constant will be given by

$T_c = (t_2 - t_1)/2.303\,[Log_{10} I(t1) - Log_{10} I(t_2)]$

By substituting the values of $Log_{10} I(t_1)$, $Log_{10} I(t_2)$, t_1 and t_2 from graph, one can able to calculates the experimental time constant Tc.

Hence experimentally calculated values of time constant Tc= RC.

From graph

i) From Vc(t) and t

$Tc_1 = t_1 + t_2/2$ = ………….. Sec

ii) From I(t) and t

$Tc_2 = t_1 + t_2/2$ = ………….. Sec

iii) From $Log_{10} I(t_1)$ and $Log_{10} I(t_2)$

$Tc_3 = t_2 - t_1/2.303[Log_{10} I(t_1) - Log_{10} I(t_2)]$ = ……..…. = ………… Sec

iv) Average Tc= $(Tc_1 + Tc_2 + Tc_3)/3$ = ………… = …………..…. Sec

Theoretical value of time constant Tc= RC = ……. * ……. = …………… Sec

Percentage Error= (Theoretical value of Tc - Experimental value of Tc) / Theoretical value of Tc * 100 = …%

Calculation Table:

S. No.	Experimental value of Tc				Theoretical value of Tc (Sec)	% error
	From Vc(t)-t graph (Sec)	From I(t)- t graph (Sec)	From Log10 I(t1)-t graph (Sec)	Average Tc (Sec)		

Result:

S. No.	Experimental value of Tc				Theoretical value of Tc (Sec)	% error
	From Vc(t)-t graph (Sec)	From I(t)- t graph (Sec)	From Log10 I(t1)-t graph (Sec)	Average Tc (Sec)		

Precautions:

1. The values of resistance R and capacity C must be so chosen that the time constant of circuit in large ie = 100 to 200 Sec.
2. It is not possible to take voltmeter reading and ammeter reading simultaneously. Hence voltmeter and ammeter reading should be taken one after the other.
3. While discharging the condenser, current decreases quite quickly. Therefore, note current reading quickly and accurately.
4. The reading of stopwatch should be taken very carefully.
5. As the stopwatch is not synchronized with the apparatus, we should be more careful in manual reading.

Viva voce :

Q. 1. What is condenser?

Ans. It is a pair of conductors of opposite charges, on which sufficient quantity of charge may be accommodated.

Q. 2. Define the capacity of condenser?

Ans. The capacity of a condenser is numerically equal to that electric charge which raises its potential by unity.

Q. 3. What is the unit of capacity?

Ans. The unit of capacity is farad.

Q. 4. What is time constant of R-C circuit?

Ans. The product R-C is called time constant of the circuit. It is equal to the time taken by the condenser to raise its charge to 0.63 of its maximum value.

Q. 5. Can you define time constant in terms of discharge of capacitor?

Ans. Yes. It is equal to time taken by condenser to reduce its charge to 0.37 of its maximum value.

Q. 6. What value of time constant will you choose if quick discharge is desired?

Ans. Low value of RC.

Q. 7. Mention the factors on which the capacity of a condenser depends?

Ans. It depends upon the following factors-

(a) Shape or area of the plates.

(b) Distance between the plates.

(c) Dielectric medium between the plates.

Q. 8. What will happen if R is reduced to zero in an RC circuit?

Ans. The charging or discharging will take place instantly.

Q. 9. Mention one important application of RC circuit?

Ans. It is used to quench the discharge in nuclear detectors specially in given counter.

Q.10. Does any other current correspond to charging and discharging of a capacitor?

Ans. Yes, it is called as displacement current. Due to time varying electric field between the plates, an electric current also flows across the space between the plates of a condenser. This current is known as the displacement current and is defined as ID = $(\varepsilon_0)d\phi/dt = (\varepsilon_0 A)dD/dt$.

Experiment No.: 8

OBJECT: - To measure the Numerical Aperture of an Optical Fiber.

APPRATUS: -Laser source, Laser power supply, Optical Fiber, Two holder for optical fibre with uprights, screen, optical bench

THEORY AND FORMULA:-

If a light ray is incident an one of the fiber at an angle of α with the normal. Then it follows from the Snell's law

$$n_0\sin\alpha = n_1\sin\beta = n_1\sin(90-\gamma) = n_1\cos\gamma$$

where n_0 is the refractive index of the medium outside. The optical fiber n_1 and n_2 are the refractive index of the material of the core and the cladding then for angle of incidence γ at the cladding layer $\gamma \geq i_c$

Hence $\cos\gamma \leq \cos i_c$

or $\leq \sqrt{(1-\sin^2 i_c)}$

or $\leq \sqrt{[1-(n_2/n_1)^2]}$ as $\sin i_c = n_2/n_1,$

or $n_1\cos\gamma \leq \sqrt{[(n_1)^2 - (n_2)^2]}$

or $n_0\sin\alpha \leq \sqrt{[(n_1)^2 - (n_2)^2]}$

at angle of critical incidence (i_c)and numerical aperture (NA) of the fiber is given by

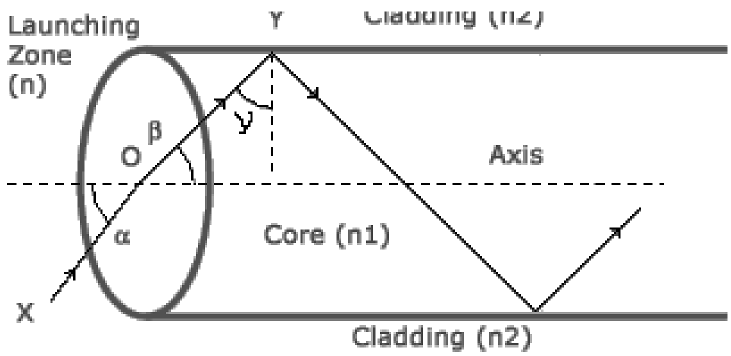
$$NA = \sqrt{n_1^2 - n_2^2}$$

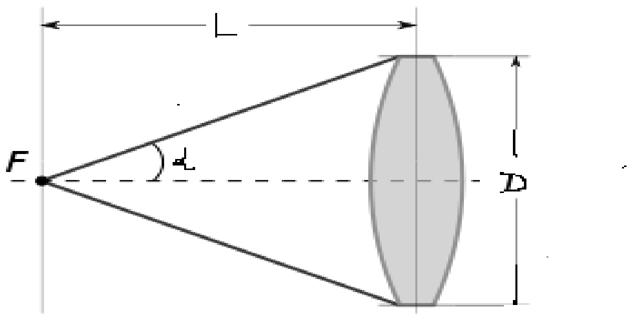
As $n_0 = 1$ in air, $NA = \sin\alpha$

$$NA = \frac{D}{\sqrt{4f^2 + D^2}}$$

Where D is Diameter of the circle and L is the Distance between screen & optical fiber cable.

Figure:-





PROCEDURE:-

Measurement of Numerical Aperture –

1. Switch on the laser source and adjust it properly so as to focus the laser on one end of the optical fibre
2. Keep a white screen with concentric circles in a vertical position with radii 05,7.5,10,12.5,15…..mm) .
3. Adjust the distance of the screen so that the spot coincide with one of the concentric circles
4. Distance f of white screen from the optical fiber end are measured, when light spot coincides with one of the concentric circle of diameter D.
5. Calculate the numerical aperture.

OBSERVATION:-

S.No.	f (cm)	D (cm)	NA	θ (degree)
1				
2				
3				
4				
5				

CALCULATIONS:-

Compute NA from the formula

Numerical Aperture = $D/\sqrt{(4f^2 + D^2)}$ = $\sin\theta$

RESULT: - The Numerical Aperture of given optical fiber (at 632.8 nm wave length) = ………..

PRECATIONS:-

1. Attach the fiber optical cord properly.
2. Distinguish the outer and inner pink light spots and thus make measurement of D.
3. Make sure that the wave length selected is 660mm. As the wave length 850mm corresponds to IR rays and defection mechanism for which is altogether different.

VIVA –VOCE

1. What is optical fiber?

Ans. Optical fiber is a ultra –thin cylindrical wavelength made of fiber glass/plastic through which optical or microwave single can be transmitted.

2. On what principle it is based?

Ans. It is based on the principle of total internal reflection.

3. What are the various parts of the optical fiber?

Ans. Optical fiber consists of three parts:

Core: It is the innermost region having diameter of the order of few micron.

Cladding: Core is surrounded by a material of slightly lower refractive index called cladding.

Protective jacket: Cladding is surrounded by another layer called jacket. It is made of plastic or polymer.

4. What is the purpose of cladding?

Ans. Cladding makes the light to confine within the core that is why the refractive index of cladding is always kept lower then that of the core.

5. What is the purpose of protective jacket?

Ans. The protective jacket provides protection agnist moisture, crushing and other environmental damages.

6. Why ultra pure glass is required in the manufacture of optical fiber ?

Ans. Because a tiny impurity in the fibre could cause the light pulse to lose its power.

7. What is numerical aperture?

Ans. It us measure of amount of light that can be accepted to pass through the fiber.

8. On what factors it depends?

Ans. It depend s only on the refracture index of core and cladding materials.

9. What is acceptance angle?

Ans. Acceptance angle α =sine$^{-1}(\sqrt{n^2 1 - n^2 2})$ .This angle is a measure of light gathering power of the optical fiber.

10. What are the characteristic features of optical fiber?

Ans. (i) Extremely low of attenuation
(ii) Flexibility
(iii) High capacity of transmitting information
(iv) No signal leakage
(v) Total immunity to of external damages
(vi) Small size and weight
(vii) Electric insulation

11. What is core?

Ans. The light- conducting central portion of an optical fiber, composed of material with a higher index of reflection then the cladding. The portion of the fiber that transmits light.

12. What is cladding?

Ans. Material surrounds the core of an optical fiber .Its lower index of reflection, compared to that of the core, causes the transmitted light to travel down the core.

13. What is coating?

Ans. The material surrounding the cladding of a fiber. Generally a soft plastic material that protects the fiber from damage.

14. What is physical meaning of 'numerical aperture'?

Ans. It means light gathering capacity.

15. Why ordinary light is incoherent?

Ans. Normally, spontaneous emission dominated stimulated emission.

16. What type of information can be sent through fiber optic cable?

Ans. Through fiber optic cables video, audio speech, text material and computer data can be transmitted.

17. What are the applications of optical fiber?

Ans. Optical fiber are widely used in fiber-optic combination, which permits remission over longer distance and at higher data rates that other form of communications . Optical fibers are also used to form sensors and a variety of other applications.

18. What is multimode fiber?

Ans. Fiber which supports many propagation paths or transverse modes are called multimode fiber MMF). Multimode fibers generally have a large –diameter core, and used for short-distance communication links or for applications where high power must be transmitted.

19. What is single mode fiber?

Ans. Fibers which support only a single mode are called single mode fiber (SMF) Single mode fibers are used for most communication links that 200 meters.

20. What are differences between optical fiber cable and copper cable?

Ans. Traditional copper cable transmits information by means of electrons. Where in fiber optic cable the information is transmitted in the form of light signals.

21. What is the relation between relative refractive index difference (Δ) and numerical aperture (NA)?

Ans. N.A. = $n_{core}\sqrt{2\Delta}$.

Experiment No.: 9

Object: To determine the coherence length and coherence time of laser using He – Ne laser.

Apparatus: Optical Bench, LASER Source, Optical Screen, Diffraction Grating.

Formula: The wave length λ of any spectral lines can be calculated by the formula:

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

$$\text{OR}\quad \mathbf{\lambda = \{(e+b)\sin\theta\}/n}$$

Where $(e + b)$ = grating element

θ = angle of diffraction

n = order of the spectrum

Coherent length L_c is given by $L_c = \lambda^2/\Delta\lambda$

For He-Ne Laser $\Delta\lambda = 0.01$ Å (given)

And coherent time τ_c is given by $\tau_c = L_c/c$

Where c is velocity of light

Diagram:

Figure 1: Energy Level Diagram of He-Ne LASER

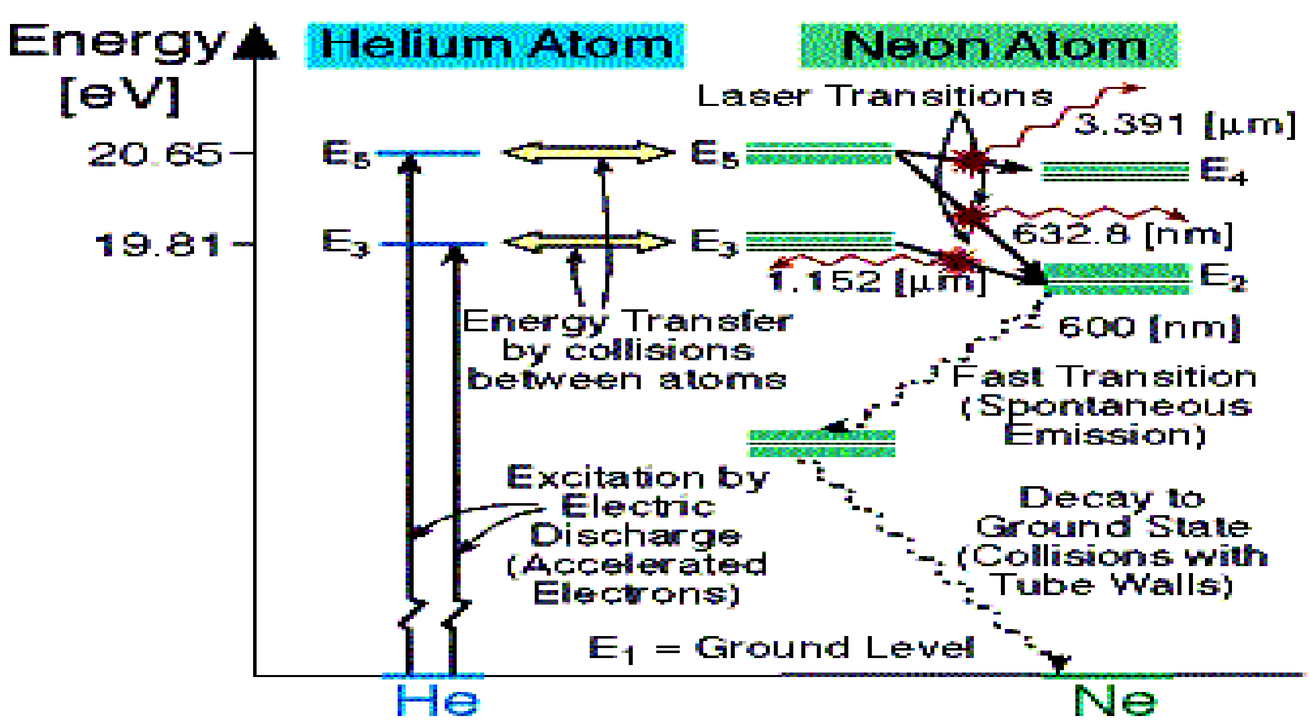
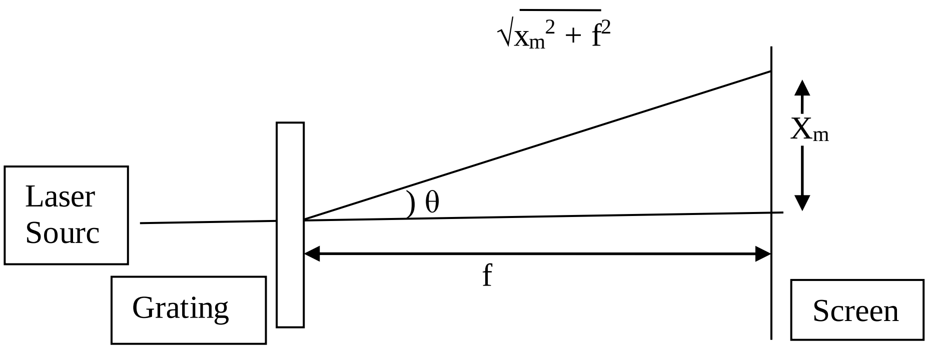


Figure: - 2. Ray Diagram



Procedure:

On the optical screen well defined spectrum is obtain. In the middle of it there is central maxima and on its either side there are formed maxima of increasing order. The distances of maximas of different order from central maxima are noted from the graph paper of optical screen and noted in observation table. The positions of riders of grating and optical screen are also noted.

Thus one can observe and record the profile of the LASER spectrum at screen.

Observation:

(1) Position of rider of diffraction grating x_1 = ………cm

(2) Position of rider of optical screen x_2 = ………cm

$X = x_2 - x_1$ = ………cm

No. of lines on grating (N) = ………… LPI

Observation Table:

S.No.	Distance between Grating & Screen f (cm)	Order of Maxima	Distance from zeroth order x_m (cm)			$\sqrt{(x^2_m + f^2)}$ (cm)	$\sin\theta = [x_m/\sqrt{(x^2_m+f^2)}]$
			R.H.S. (cm)	L.H.S. (cm)	Average x_m (cm)		
1.		I					
		II					
2.		I					
		II					
3.		I					
		II					

Calculation:

(i) Calculation of grating element :

No. of lines on grating N = …………. (LPI)

Grating element (e + b) = 2.54/N = ………………… cm

(ii) Calculation of λ

$$\lambda = [(e + b)\sin\theta]/n$$

Using this formula calculate λ for 1st , 2nd and 3nd order of spectrum. Calculate mean wave length.

$$\lambda = (\lambda_1 + \lambda_2 + \lambda_3)/3 = \text{……..cm}$$

$$= \text{………. Å}$$

Calculation of coherent length

$\Delta\lambda = 0.01$ Å (given)

$\Delta l = \lambda^2/\Delta\lambda$,

Coherent Time $\tau = \Delta l/C$

Result: The wavelength of He-Ne LASER is λ = ……… Å

Coherent length of Laser = ……. Å

Coherent Time of Laser = ….. sec.

Standard value of λ = 6328 Å

Precautions:

1. Height of LASER source, slit, lens, grating and optical screen on all riders should be same.
2. All riders must be aligned along one common axis.
3. Slit, grating and optical screen should be vertical and parallel to each other.
4. Grating should be fixed for normal incidence.

Viva-Voce:

Q.1 What is laser?

Ans. It is a device to produce a strong monochromatic, collimated and highly coherent beam of light.

Q.2 What is meant of laser?

Ans. The word LASER is an acronym for "Light Amplification by Stimulated Emission of Radiation".

Q.3 What is the principle of laser?

Ans. The laser works on the principle of stimulated emission or induced emission. It emits coherent light by population inversion

Q.4 What is the difference between mercury source and laser source?

Ans. Comparison between Mercury Source and Laser Source

(a) Light emitted from mercury light source is all direction while laser source produces light emitting in only one direction.

(b) When mercury light passes through the grating it produces line spectrum while light from laser sources produces spots.

(c) Laser source higher order maxima can observed but mercury source have limit up to second order maxima.

Q.5 Is He-Ne laser is four energy level laser system?

Ans. Yes, He-Ne laser is four energy level system.

Q.6 Give an example of three level laser.

Ans. Ruby laser

Q.7 Define the coherence time.

Ans. The average time interval for which the field remains sinusoidal (means definite phase relationship exists) is known as "coherence time" or temporal coherence" of the light beam.

Q.8 Define the coherence length.

Ans. The average length of wave trains for which the field is sinusoidal is known as "coherent length" or "longitudinal coherent length".

Q.9 Mention the basic characteristics of laser light source.

Ans. Laser light is monochromatic, high intense, directional and coherent.

Q.10 What do you mean by solid angle?

Ans. The angle subtended by an area to a certain point is called solid angle.

Solid angle $\theta = A/r^2$

Q.11 What is wavelength of light emitted from He-Ne laser?

Ans. The wavelength of light emitted by He-Ne laser is 6328 Å.

Q.12 What do you mean by spontaneous emission?

Ans. This is a process in which a light source such as an atom molecule or nucleus in an excited state undergoes a transition to a state with a lower energy, e.g. the ground state and emits a photon.

Q.13 Whit do you mean by stimulated emission?

Ans. In this process, a photon interacts with the atom in an excited state., and two atoms drop to a lower energy level. A photon created in this manner has the same phase, frequency, polarization and direction of travel as the photon of the incident wave.

Q.14 What do you mean by ‘Population Inversion’.

Ans. It means number of atoms in higher energy level greater than the number of atoms in lower energy level.

Q.15 Which is the active gas in He-Ne gas laser?

Ans. Ne gas

Q.16 Define metastable state.

Ans. In a state that is not truly stationary but is almost stationary. The life time of metastable in unusually long (10^{-3} Sec.).

Q.17 What type of pumping source we use in He-Ne gas laser?

Ans. Electric discharge.

Q.18 What is the role of diffraction grating in your experiment?

Ans. It diffraction the incident laser light

Q.19 How many orders do you achieve in your experiment?

Ans. 2 order.

Q.20 In which state stimulated emission takes place in He-Ne gas laser?

Ans. $E_6 \rightarrow E_3$

Experiment No.: 10

Object:

1. To determine the Hall voltage developed across the sample material.
2. To calculate the Hall coefficient and the carrier concentration of the sample material.

Apparatus:

Two solenoids, Constant current supply, Four probe, Digital gauss meter, Hall effect apparatus (which consist of Constant Current Generator (CCG), digital milli voltmeter and Hall probe).

Theory:

If a current carrying conductor placed in a perpendicular magnetic field, a potential difference will generate in the conductor which is perpendicular to both magnetic field and current. This phenomenon is called Hall Effect. In solid state physics, Hall effect is an important tool to characterize the materials especially semiconductors. It directly determines both the sign and density of charge carriers in a given sample.

Consider a rectangular conductor of thickness ***t*** kept in XY plane. An electric field is applied in X-direction using Constant Current Generator (CCG), so that current ***I*** flow through the sample. If ***w*** is the width of the sample and ***t*** is the thickness. There for current density is given by

$$J_x = I/wt \qquad (1)$$

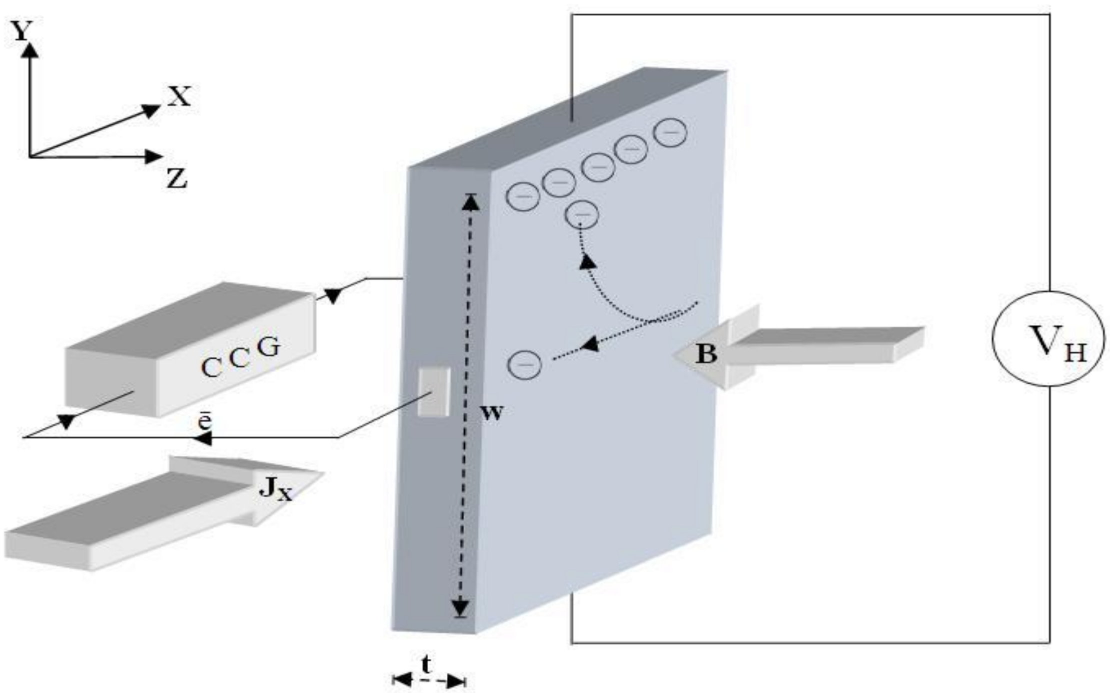


Fig.1 Schematic representation of Hall Effect in a conductor.

CCG – Constant Current Generator, $\boldsymbol{J_X}$ – current density
$\bar{e}$ – electron, ***B*** – applied magnetic field
t – thickness, ***w*** – width
$\boldsymbol{V_H}$ – Hall voltage

If the magnetic field is applied along negative z-axis, the Lorentz force moves the charge carriers (say electrons) toward the y-direction. This results in accumulation of charge carriers at the top edge of the sample. This set up a transverse electric field $\mathbf{E}_y$ in the sample. This develop a potential difference along y-axis is known as Hall voltage $\boldsymbol{V_H}$ and this effect is called Hall Effect.

A current is made to flow through the sample material and the voltage difference between its top and bottom is measured using a volt-meter. When the applied magnetic field B=0,the voltage difference will be zero.
We know that a current flows in response to an applied electric field with its direction as conventional and it is either due to the flow of holes in the direction of current or the movement of electrons backward. In both cases, under the application of magnetic field the magnetic Lorentz force, $F_m = q(v x B)$ causes the carriers to curve upwards. Since the charges cannot escape from the material, a vertical charge imbalance builds up. This charge imbalance produces an electric field which counteracts with the magnetic force and a steady state is established. The vertical electric field can be measured as a transverse voltage difference using a voltmeter.
In steady state condition, the magnetic force is balanced by the electric force. Mathematically we can express it as

$$eE = evB \tag{2}$$

Where 'e' the electric charge, 'E' the hall electric field developed, 'B' the applied magnetic field and 'v' is the drift velocity of charge carriers.

And the current 'I' can be expressed as,

$$I = neAv \tag{3}$$

Where 'n' is the number density of electrons in the conductor of length l ,breadth 'w' and thickness 't'.

Using (1) and (2) the Hall voltage V_H can be written as,

$$V_H = Ew = vBw = \frac{IB}{net}$$

$$V_H = R_H \frac{IB}{t} \tag{4}$$

by rearranging eq(4) we get

$$R_H = \frac{V_H * t}{I * B} \tag{5}$$

Where R_H is called the Hall coefficient.

$$R_H=1/ne \qquad (6)$$

Procedure:

- Connect 'Constant current source' to the solenoids.
- Four probe is connected to the Gauss meter and placed at the middle of the two solenoids.
- Switch ON the Gauss meter and Constant current source.
- Vary the current through the solenoid from 1A to 5A with the interval of 0.5A, and note the corresponding Gauss meter readings. Set 1000 gauss magnetic field
- Switch OFF the Gauss meter and constant current source and turn the knob of constant current source towards minimum current.
- Fix the Hall probe on a wooden stand. Connect green wires to Constant Current Generator and connect red wires to milli voltmeter in the Hall Effect apparatus
- Replace the Four probe with Hall probe and place the sample material at the middle of the two solenoids.
- Switch ON the constant current source and CCG.
- Carefully increase the current I from CCG and measure the corresponding Hall voltage V_H. Repeat this step for different magnetic field B.
- Thickness t of the sample is measured using screw gauge.
- Hence calculate the Hall coefficient R_H using the equation 5.
- Then calculate the carrier concentration n. using equation 6.

Observation : Then calculate Hall coefficient and carrier concentration of that material using the equation

$$R_H=V_H\, t/(I*B)$$

Where R_H is the Hall coefficient

$$R_H=1/ne$$

And n is the carrier concentration

- Repeat the experiment with different magnetic file.

Observation Table:

Serial No:	Magnetic Field (Gauss)	Thickness (t) m	Hall current, mA	Hall Voltage mV	R_H
1					
2					
3					
4					
5					

Result

Hall coefficient of the material = ...

Carrier concentration of the material =.......................... m^{-3}

Precautions:

Personal

- The magnet power supply can furnish large currents at dangerous voltage levels; do not touch exposed magnet coil contacts.
- The oven gets hot.
- AC leads from Variac to oven can be dangerous; they should not be exposed.

Apparatus

- Never suddenly interrupt or apply power to a large magnet. Large inductive voltage surges may damage the insulation. Start with controls set for zero current and gradually increase current. When turning off, smoothly decrease current to zero and then turn off.
- Turn on water before turning on magnet coil.
- Do not exceed magnet current of 10 A.
- Do not exceed Hall probe current of 0.4 A
- Do not exceed an oven temperature of 100°C (a few degrees more for a brief time will do no harm).
- Do not leave the magnet current at a high setting for any length of time beyond the minimum needed for data acquisition - it affects the monitor (obviously).

Viva-Voce:

What is Hall Effect?

Ans. When a current carrying conductor is placed in a magnetic field mutually perpendicular to the direction of current a potential difference is developed at right angle to both the magnetic and electric field.

This phenomenon is called Hall effect.

Define hall co-efficient.

*Ans. It is numerically equal to Hall electric field induced in the specimen crystal by unit current when it is placed perpendicular in a magnetic field of 1 weber/(meter*meter).*

Define mobility.

Ans. It is the ratio of average drift velocity of charge carriers to applied electric field.

Why is Hall potential developed?

Ans. When a current carrying conductor is placed in a transverse magnetic field the magnetic field exerts a deflecting force (Lorentz Force) in the direction perpendicular to both magnetic field and drift velocity this causes charges to shift from one surface to another thus creating a potential difference.

What is Fleming's Left Hand Rule?

Ans. Stretch thumb, first finger, middle finger at right angles to each other such that fore finger points in the direction of magnetic field, middle finger in the direction of current then thumb will point in the direction of the force acting on it.

How does mobility depend on electrical conductivity?

Ans. It is directly proportional to conductivity.

Define Hall angle.

Ans. It is the angle made with the x direction by the drift velocity of charge carrier is known as hall angle.

Which type of charge has greater mobility?

Ans. In semiconductors, electron has greater mobility than holes.

What happens to the hall coefficient when number of charge carriers is decreased?

Ans. Hall coefficient increases with decrease in number of charge carriers per unit volume.

Name one practical use.

Ans. It is used to verify if a substance is a semiconductor, conductor or insulator. Nature of charge carriers can be measured.