Lab Manuals For Physics Lab

B.Tech I Year

Sub.:- Engg. Physics

(PHL 0101 / PHL0201)

DEPARTMENT OF PHYSICS

I.T.M.UNIVERSITY

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LIST OF EXPERIMENTS

Sub.:-Engg. Physics **Sub.:- (PHL0101/PHL0201)**

1. To determine the specific rotation of cane sugar solution with the help of polarimeter.
2. To determine Planck's constant using light emitting diodes [LED's] by observing the '*reverse photo-electric effect*'.
3. To determine the dispersive power of the material of the prism using mercury light with the help of a spectrometer.
4. To study the Hall Effect and to calculate:-
   (i) The Hall Coefficient (R_H) (ii) The concentration of charge carriers
5. To determine the wavelength of laser light using Diffraction Grating.
6. To draw the characteristic curves of a forward & reverse Biased P-N junction diode and to determine the static resistance of the given diode.
7. To Determination of the Resolving Power of a Telescope.
8. To determine the wavelength of sodium light by Newton's Ring.
9. To determine the Energy Band Gap of a Semiconductor by using a Junction Diode.
10. To measure the numerical aperture of the given an optical fiber.
11. To verify Inverse square law of light using a photo cell.

EXPERIMENT NO. 1

Object: - To determine the specific rotation of cane sugar solution with the help of Polarimeter.

Apparatus Required: - Polarimeter, a balance, measuring cylinder, beaker, source of light and Polarimeter tube.

Formula used: - The specific rotation of the plane of polarization of sugar dissolved in water can be determined by the following formula.

$$S = \frac{\theta \times V}{m \times l}$$

Where, θ = rotation produced in degrees.

l = length of tube in decimeter.

m = mass of sugar in gms dissolved in water.

V = volume of sugar solution.

Figure

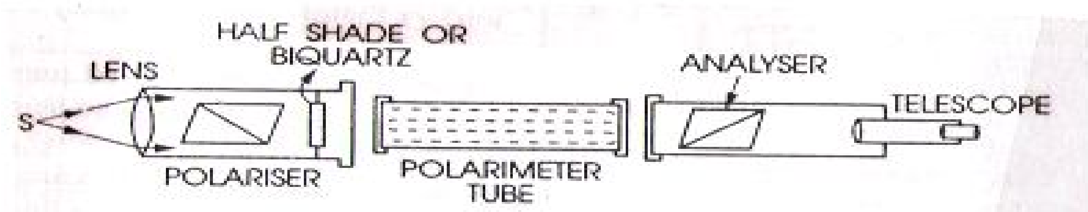


Fig.

Procedure: -

1. If the polarimeter is employing a half shade device, a monochromatic source should be used and if bi quartz device is used then white light can be used.
2. Take the polarimeter tube and clean well both the sides such that it is free from dust. Now fill the tube with pure water and see that no air bubble is enclosed it. Place the tube in its position inside the Polarimeter.
3. Switch on the source of light and look through the eyepiece. Two halves of unequal intensity is observed. Rotate the analyzer until two halves of the field appears equal bright. Take the reading of main scale as well as vernier scale and find out the total reading.
4. Prepare the sugar solution of unknown strength. The procedure for preparing it can be seen under the heading observations.
5. Take the polarimeter tube and remove the pure water and fill it with the prepared sugar solution and again place it in the polarimeter.
6. Rotate the analyzer to obtain the equal intensity position, first in clockwise direction(I reading) and then in anti-clockwise direction(II Reading).

   [When the tube containing sugar solution is placed in the path of the polarized light, the plane of polarization is rotated which disturbs the previous position.]

   Note down the position of the analyzer on main and vernier scales in the two directions. Find the mean reading. The difference between this and previous reading gives the specific rotation.
7. Repeat the experiment with the sugar solutions of different concentrations.
8. Measure the length of the tube in centimeters and change it in decimeters.

Observation: - 1. Least count of polarimeter = 0.1 deg = 6 minute

2 . Length of l polarimeter tube = 2.1 dm

Analyzer reading with pure water						
I Reading			II Reading			A= (X+Y)/2 deg
M.S.	V.S.	Total X deg	M.S.	V.S.	Total Y deg	

Concentra-tion of sugar solution C= m/V	Analyzer reading with sugar solution							
	I Reading			II Reading			B = (X'+Y')/2 deg	θ=A~B
	M.S.	V.S.	Total X' deg	M.S.	V.S.	Total Y' deg		

Calculations: -

$$S = \frac{\theta \times V}{m \times l}$$ = --------------deg/dm/kg/m³

Result: - The specific rotation for cane sugar at a room temperature using monochromotic light is ----------

Percentage error:

$$\% \text{ ERROR} = \frac{(\text{Standard value} \sim \text{Observed Value}) \times 100}{\text{Standard Value}}$$

Precaution:-

1. The polarimeter tube should be well cleaned.
2. Whenever solution is changed, rinse the tube with the new solution under examination.
3. The position of analyzer should be set accurately.
4. The temperature and wavelength of light used should be stated.
5. Reading should be taken when halves of the field of view becomes equally illuminate.

Viva Questions

Ques 1 . What do you mean by polarization?

Ans. The lack of symmetry about the direction of propagation of light is known as the polarization of light.

Ques 2. What are optical rotations?

Ans . The rotations produced by a decimeter long column of the liquid containing 1 gm of active substance in 1 cc of the solution.

Ques 3, What is Brewster's law of polarization?

Ans. The tangent of the polarizing angle is mathematically equal to the refractive index of the material i.e $\mu = \tan(i_p)$

Ques 4. Define plane of vibration and plane of polarization.

Ans. The plane of polarization is that plane in which no vibrations occur and the plane in which vibrations occur known as plane of vibration. The vibrations occur at the right angle to the plane of polarization.

Ques 5. What do you mean by double refraction?

Ans. When a ray of light is refracted by a crystal of calcite it gives two refractive rays .this phenomenon is known as double refractions.

Ques s6. What is nicol prism?

Ans. It is an optical device which is made by calcite crystal to produce and analyze the plane polarized light .

Ques 7. What do you mean by Snell's law?

Ans. The sine of the angle of incidence to sine of the angle of refraction is equal to the refractive index of the material.

Ques 8.What is mean by plane polarized and unpolarized light?

Ans. The plane polarized light is the light in which the vibrations take place only along one straight line perpendicular to the direction of propagation of light while in unpolarized light vibrations take place along all possible straight lines perpendicular to the direction of propagation of light.

Ques9. What are the ordinary and extra ordinary lights?

Ans .Ordinary light obeys Snell's law while extra ordinary doesn't obey the Snell's law.

Ques10. Define refractive index.

Ans. It is the ratio of velocity of light in vacuum to the velocity of light in any medium.

$$\mu = c / v$$

Experiment No. 2

Object: - To determine Planck's constant using light emitting diodes [LED's] by observing the '*reverse photo-electric effect'*.

Apparatus Required:- Planck's Constant kit and LED's

Theory: The energy of a photon is given by the equation:

$$E = h\upsilon \qquad \text{........(1)}$$

Where E is the energy of photon υ is its frequency, and h is a constant. In the case of the photoelectric effect, an electron is emitted from a metal if the energy of the photon is greater than the work function of the metal. If the energy of said photon is greater than the work function of a given material then the electron emitted possesses a voltage, which equals the difference in these energies. In the case of an LED's the opposite is true. If an electron of sufficient voltage is passed across a material then a photon is emitted whose energy is equivalent to the work function of that material. The voltage at which this effect observed is the 'turn on voltage'. This effect is not normally observed in metals and other typical substances because the photons emitted are usually outside the range of visible light, usually somewhere in the infrared. The energy of the photons emitted should then be the same as the energy of a given electron. Since:

$$P = IV \qquad \text{....... (2)}$$

Where P is power, I is current and V is the voltage of a system. The energy of one electron is the charge of an electron (i.e. the current flow of one electron per second in amps) times the voltage. Using this knowledge we then from the equation:

$$E = eV \qquad \text{......... (3)}$$

Where, $e = 1.6 \times 10^{-19}$ C (electron charge)

We then solve equation (1) for h and replace the E term with the equivalent of E in equation (3), as well as replace υ with:

$$\upsilon = \frac{c}{\lambda} \qquad \text{...... (4)}$$

Where $c = 3\times10^{8}$ m/sec (speed of light)

We then get:

$$h = \frac{eV\lambda}{c} \qquad \text{...... (5)}$$

This equation we will use to determine Planck's constant.

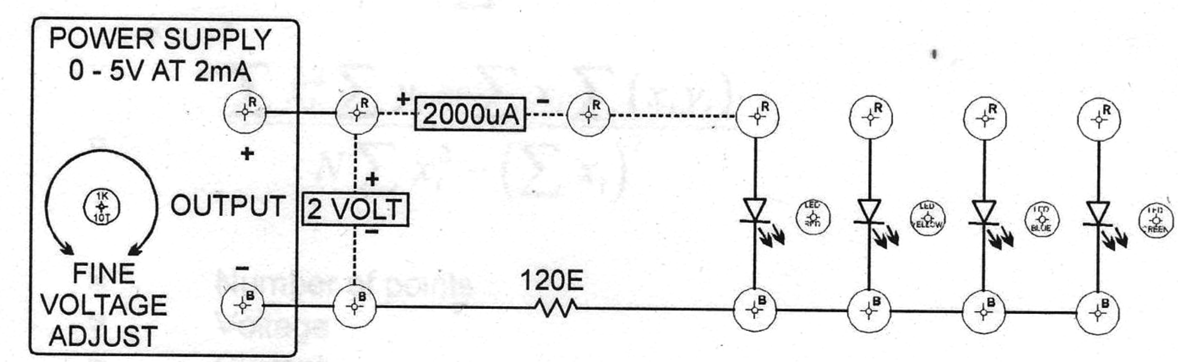


Figure: Planck Constant

Procedure:

1. Make the connection in the kit as shown in the figure 1.
2. Take the current measurement of each LED by varying the voltage as given in the table.
3. Plot the curve on the graph paper between Voltage on X axis and current on Y axis.
4. The linear portion of the I/V curve is extra plotted back to the X axis .

5. The intercept is the point at which the voltage equals to the barrier potential. Put this value in table 2.

Observation Table:

S.No.	Voltage (Volts)	Current I_{Red} (μA)	Current I_{yellow} (μA)	Current I_{Green} (μA)	Current I_{Blue} (μA)
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Calculation:

S. No.	L.E.D. Colour	Voltge V [Volts]	Wavelength λ [nm]	Frequency [Hz] $f = c/\lambda$	Energy [J] $E = eV$
1	Blue		430		
2	Green		565		
3	Yellow		590		
4	Red		627		

Planck's Constant is $h = \frac{E}{f} = \frac{e.V.\lambda}{c}$

Where c = 3×10^{8} m/sec (speed of light)

e = 1.6×10^{-19} C (electron charge)

Result:

Observed value of Planck's constant is h=…………………Js.

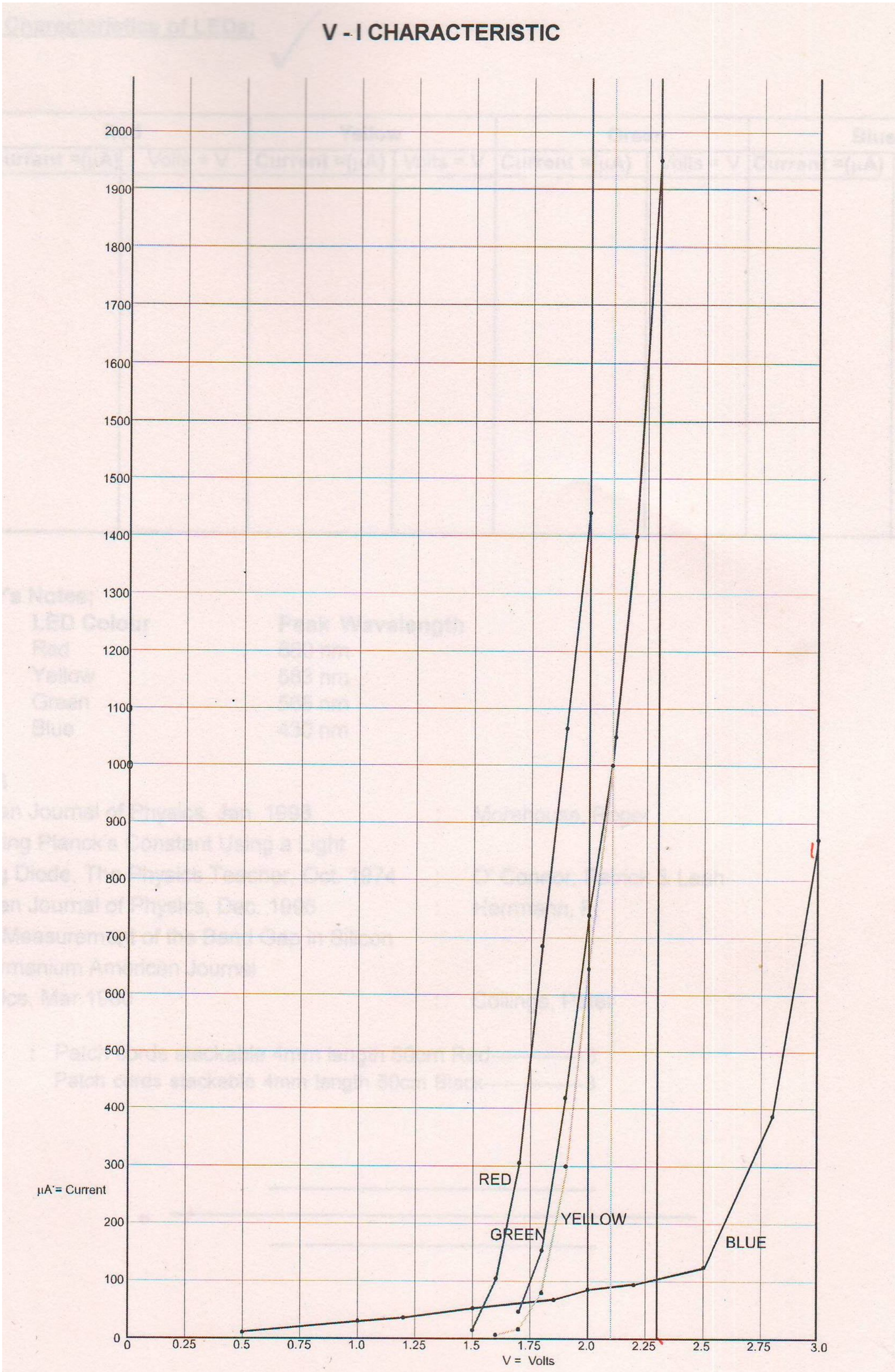
Percentage error:

$$\% \text{ ERROR} = \frac{(\text{Standard value} \sim \text{Observed Value}) \times 100}{\text{Standard Value}}$$

Source of Error:-

1. Some noise may be created in the system during Experiment which can be minimized by immersing the diode in the Ice during Experiment [if available].
2. Connect the LED properly to Jack provided on front panel.

Graph


V - I CHARACTERISTIC
µA = Current
V = Volts
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1500
1600
1700
1800
1900
2000
0
0.25
0.5
0.75
1.0
1.25
1.5
1.75
2.0
2.25
2.5
2.75
3.0
RED
GREEN
YELLOW
BLUE

VIVA-VOCE

Q.1. Define Photoelectric effect?

Ans: When light falls on metal surface, an electron is emitted from a metal if the energy of the photon is greater than the work function of the metal.

Q.2 What is Reverse Photoelectric effect?

Ans: If an electron of sufficient voltage is passed across a material then a photon is emitted whose energy is equivalent to the work function of that material. The voltage at which this effect observed is the 'turn on voltage'. In case of LED reverse photoelectric effect works.

Q.3 Can we observe reverse photoelectric with Metal surface?

Ans : This effect is not normally observed in metals and other typical substances because the photons emitted are usually outside the range of visible light, usually somewhere in the infrared Range.

Q.4 What is the full form of LED?

Ans: Full form of LED is Light Emitting Diode.

Q.5 What is the standard value of h.

Ans: $h = 6.6 \times 10^{-34}$ Js.

Q.6: What is LED?

Ans: A **light-emitting diode** (**LED**) is a semiconductor device that emits visible light when an electric current passes through it.

Q.7 What is the learning outcome of this practical?

Ans: Using this practical we can find out the value of Planck constant using LED.

EXPERIMENT NO. 3

Object: - To determine the dispersive power of the material of the prism using mercury light with the help of a spectrometer.

Apparatus required: - Spectrometer, prism, mercury Source and reading lens.

Theory:

(a) Diagram:-

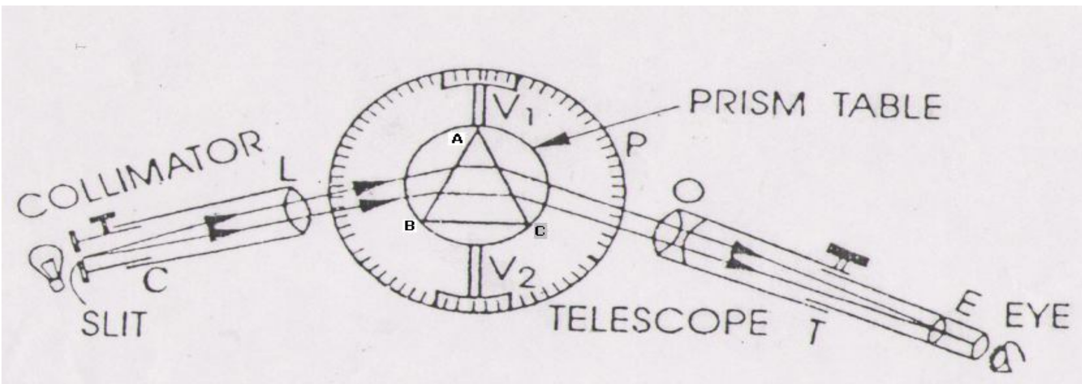


Fig.

(b) Formula used: - The dispersive Power 'ω' of the material of the prism is given by the formula

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

Where, μ_v = refractive index of the material of the prism for violet colour,

μ_r = refractive index of the material of the prism for red colour,

$$\mu_y = \frac{\mu_v + \mu_r}{2}$$

The refractive index of the prism is given by

$$\mu = \frac{Sin\left(\frac{A + \delta m}{2}\right)}{Sin\left(\frac{A}{2}\right)}$$

Where, A = Angle of the prism, δm = Angle of minimum deviation

Procedure:

MEASUREMENT OF THE ANGLE OF THE PRISM

1. Determine the least count of the spectrometer.
2. Place the prism on the prism table with its refracting angle A towards the collimator and with its refracting edge at the center. In this case some of the light failing on each face will be reflected and can be received with the help of the telescope.
3. The telescope is moved to one side to receive the light reflected from the face AB and the cross wire are focused on the image of the slit. The readings of the two verniers are taken.
4. The telescope is moved in other side to receive the light from the face AC and again the cross wire are focused on the image of the slit. The readings of two vernier are noted.
5. The angle through which the telescope is moved or the difference in the two positions gives twice the refracting angle A of the prism. Therefore, half of this angle gives the refracting angle of the prism.

MEASUREMENT OF THE ANGLE OF MINIMUM DEVIATION

1. Place the prism so that its centre coincide with the centre of the prism table and light falls on one of the polished faces and emerges out of the other polished face, after refraction. In this position the spectrum of light is obtained.
2. The spectrum is seen through the telescope is adjusted for minimum deviation position for a particular colour (wavelength) in the following way: -

   Setup telescope at a particular colour and rotate the prism table in one direction, of course the telescope should be moved in such way to keep the spectral line in view. By doing so a position will come where the spectral line recedes in the opposite direction although the rotation of the table is continued in the same direction. The particular position where the spectral line begins to recede in opposite direction is the minimum deviation position for that colour. Note the reading of the two verniers.

3. Remove the prism table and bring the telescope in the line of the collimeter. See the slit directly through telescope and coincide the image of slit with vertical crosswire. Note the readings of two verniers.
4. The difference in minimum deviation position and direct position gives the angle of minimum deviation for that colour.
5. The same procedure is repeated to obtain the angles of minimum deviation for other colors.

Ovservation table

Table for angle [A] of the prism

<table>
<tr><th>S.No.</th><th>Vernier</th><th colspan="3">Telescope reading for reflection from first face</th><th colspan="3">Telescope reading for reflection from second face</th><th rowspan="2">2A= a~b deg.</th><th rowspan="2">Mean 2A deg.</th><th rowspan="2">A deg.</th></tr>
<tr><td></td><td></td><td>M.S. deg.</td><td>V.S. deg.</td><td>TOTAL (a) deg.</td><td>M.S. deg.</td><td>V.S. deg.</td><td>TOTAL (b) deg.</td></tr>
<tr><td rowspan="2"></td><td>V_1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>V_2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Table for angle of minimum deviation δ_m

S. No	Color	Vernier	(Dispersed image) Telescope in minimum deviation position			Telescope reading for direct image			Deviation a~b	Mean deviation δ_m deg
			M.S. deg.	V.S. deg.	TOTAL (a) deg.	M.S. deg.	V.S. deg.	TOTAL (b) deg.		
1	Violet	V_1								
		V_2								
2	Yellow	V_1								
		V_2								
3	Red	V_1								
		V_2								

<u>Calculation</u>:-

$$\mu = \frac{Sin\ (\frac{A + \delta m}{2})}{Sin\ (\frac{A}{2})}$$

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

Result:

Dispersive power of material of the prism ω=...........

Percentage error:

$$\% \text{ ERROR} = \frac{(\text{Standard value} \sim \text{Observed Value}) \times 100}{\text{Standard Value}}$$

Precautions :-

1. The telescope and collimator should be individually set for parallel rays.
2. Slit should be as narrow as possible.
3. While taking observations, the telescope and prism table should be clamped with the help of clamping screws.
4. Both verniers should be read.
5. The prism should be properly placed on the prism table for the measurement of angle of the prism as well as for the angle of minimum deviation.

Viva Voce

(1) What is prism?
Ans : A transparent medium like glass bounded by two triangle and three rectangular smooth surfaces

(2) Which colour in the spectrum is having maximum and minimum refractive index?

Ans : Maximum for Violet Colour

Minimum for red colour.

(3) What is Refractive index?

Ans : The ratio of sine of angle of incidence in the first medium to the sine of angle of refraction in the second medium.

(4) What is the function of Collimator?

Ans : It will produce parallel beam of light.

(**5)**What do you mean by Angle of Prism?

Ans : Angle between two refracting surfaces of the prism.

(6) What is Dispersion of Light?

Ans : When the light is allowed to fall on one of the refracting surfaces of a prism , it is split into its constituent colours. This splitting of light into its constituent colours by refraction through prism is called Dispersion of light.

(7) What is the main optical action of the prism?

Ans : The main optical action of a prism is to disperse white light into its component parts. Dispersion of light is minor optical action of prism , but main effect of a prism is to deviate a beam of light.

(8) What type of material prism is used in this experiment?

Ans : Crown prism.

(9) What is the units of Dispersive power?

Ans : No units.

(**10**)What type of light do you use in this experiment?

Ans : White light with the help of mercury lamp.

EXPERIMENT NO. 4

Object: - To study the Hall Effect and to calculate:-
(i) The Hall Coefficient R_H
(ii) The concentration of charge carriers

Required Apparatus:- Power supply for electromagnets, Gauss meter with hall probes, p type Ge semiconductor on PCB, multimeter, electromagnets.

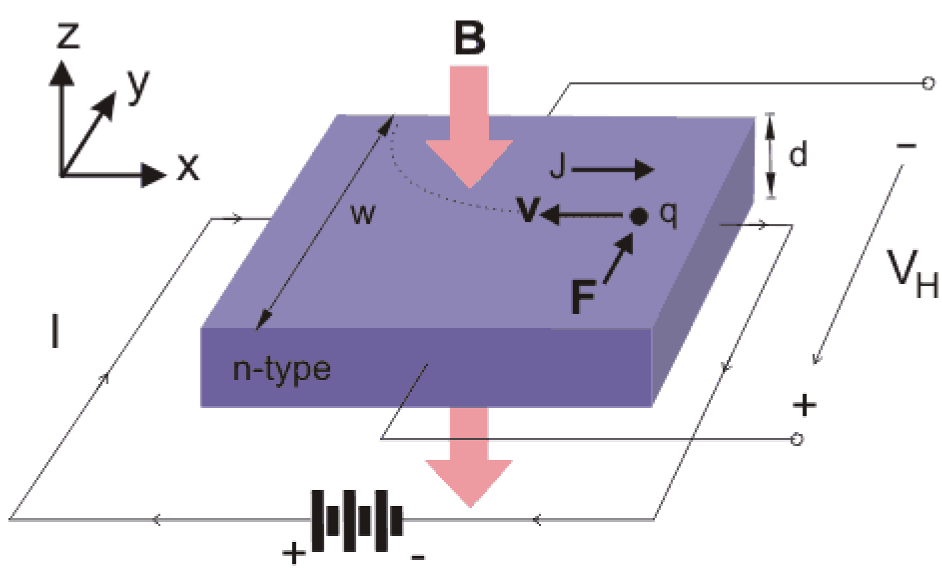
Theory: A current carrying conductor (semiconductor/metal) is placed in the magnetic field perpendicular to the direction of current; a voltage is developed across the conductor in a direction perpendicular to both the current and magnetic field. The effect is known is as Hall Effect. This effect is very useful in determining-

> The nature of charge carries e.g. whether semiconductor is on n-type or p-type

> Carrier concentration or the no. density of charge carries

> Mobility of charge carriers

Diagram:



BLOCK DIAGRAM OF EXPERIMENTAL SET-UP

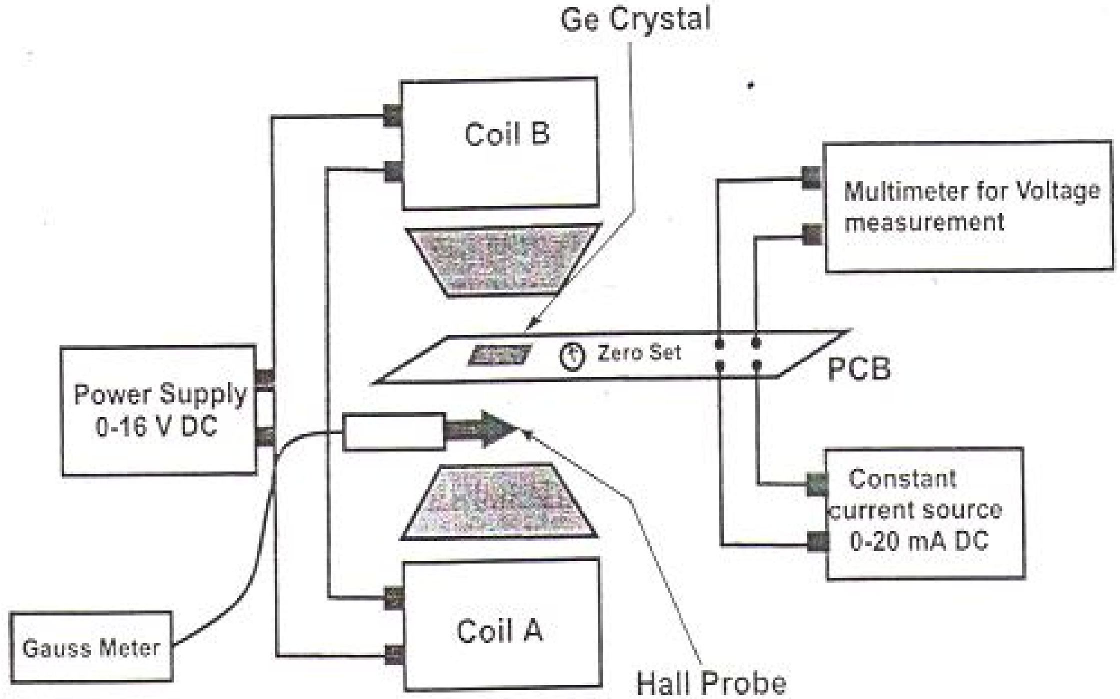


Fig. 2

Formula used

Hall Coefficient $R_H = \left(\frac{V_H}{I}\right)\frac{w}{B}$

Carrier Concentration $n = \frac{1}{eR_H}$

Procedure:-

(1) Connect one pair of contact of specimen on the opposite faces to the current source and other pair to the multimeter.

(2) Switch on the power supply of electromagnet and measure the magnetic flux density at the centre between the pole faces by placing the tip of the hall probe there. Now do not change the current in the electromagnet, i. e. keep the magnetic field constant.

(3) Place the specimen at the centre between the pole faces such that the magnetic field is perpendicular to the strip.

(4) Pass the current (mA) from the current source through the specimen and measure the resulting hall voltage in the multimeter / milivoltmeter.

(5) Increase the current through the specimen gradually and measure the corresponding Hall voltages.

(6) The entire process can be repeated for different values of magnetic flux density. Find the mean of different R_H.

Observation:- Thickness of specimen, w = 0.49 mm = 0.49×10^{-3} m
Magnetic flux density, B = --------- Gauss = ……….$\times 10^{-4}$ Tesla

S.No.	Current I [mA]	Voltage HV [mV]	Hall Coefficient [R_H]

Calculations:- **Hall Coefficient** $R_H = \left(\frac{V_H}{I}\right)\frac{w}{B}$

Mean R_H = ---------------

Carrier Concentration $n = \frac{1}{eR_H}$

Result:- **Hall Coefficient R_H =…………………**

Carrier Concentration n=……………………

Source of Error:-

(1) Before starting the experiment, check the gauss mete is showing zero value. For this put the prove in separate place and switch on the gauss meter, it will show zero meter.

(2) Ensure that the specimen is located at the centre between the pole faces and is exactly perpendicular to the magnetic field.

(3) To measure the magnetic flux the hall probe should placed at the center the pole faces, parallel to the crystal.

(4) Check the direction of electromagnet coils so that it generates the maximum magnetic field, this can be check by placing the soft iron near the generated magnetic field, if soft iron attracts forcefully the magnetic field produced is strong, otherwise magnetic field is weak.

Viva voce

Q.1 Define Hall Effect?

Ans. When a current carrying specimen is placed in a transverse magnetic field then a voltage is developed which is perpendicular to both, direction of current and magnetic field. This phenomenon is known Hall Effect.

Q.2 What causes Hall Effect?

Ans. Whenever a charge moves in a mutually perpendicular electric and magnetic field it experiences Lorentz force due to which it deflects from its path and Hall voltage is developed.

Q.3 What is Lorentz force?

Ans. If charge 'q' moves in a magnetic and electric field 'B' &'E' respectively with velocity v then force on it is given by

$F= qE+ Bqv.\sin\theta$

Q.4 What is Hall Coefficient?

Ans. It is the electric field developed per unit current density per unit magnetic field

Q.5 What are the uses of Hall Effect?

Ans. To determine the sign of charge carrier and charge carrier concentration

Q.6 Define Charge carrier concentration.

Ans. No. of charge carriers per unit volume.

Q.7 why Hall voltage differ for different type of charge carrier?

Ans. Because direction of Lorentz force is different for different type of charge carrier.

Q.8 what is unit Hall coefficient?

Ans. Ohm-meter/Tesla.

Q.9 What is the unit of charge carrier concentration

Ans. Per Cubic-centimeter.

Q10 Which type of magnet is used in the experiment, temporary or permanent?

Ans. Temporary.

EXPERIMENT NO. 5

Object:- To determine the wavelength of laser light using Diffraction Grating.

Apparatus Required:

Semi-Conductor Laser, a different grating, an optical bench and a screen.

Theory And Formula Used: A diffraction grating is an optical device which produces spectra to diffraction. It has a large no. of lines grooved on it. The spectra consisting of different orders is governed by the relation-

$$d.Sin\theta = m.\lambda$$

The no. of lines on the grating is-

$$d = \frac{2.54}{15000}$$

Wavelength of the laser light is –

$$\lambda = \frac{d.Sin\theta}{m}$$

Where d= grating constant

m=1, 2,……….(Order of spectra)

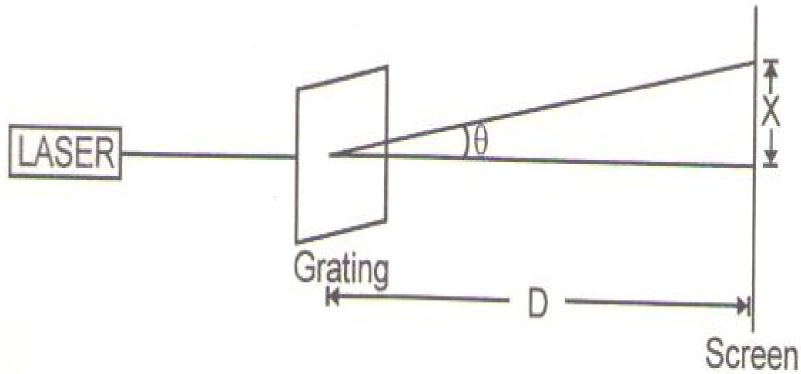


Fig.1. To determine the wavelength

Procedure:

1. Diode laser is mounted on it's saddle.
2. A plane transmitting grating is mounted on an upright next to laser.
3. The position of x of the spot of 1st order on either side of central maxima is marked.
4. The distance D between the grating and screen.

Observation Table:

S. No.	D in cm.	Order	Distance x cm.		Mean x cm.	$\sqrt{x^2 + D^2}$	$Sin\theta = \frac{x}{\sqrt{x^2 + D^2}}$
			L.H.S	R.H.S			
1.							
2.							
3.							

Calculation:

$$\lambda = \frac{d.Sin\theta}{m}$$

Where d= grating constant

m=1, 2,……….(Order of spectra)

Result:

1. The wavelength of the given LASER beam is …………………

Percentage Error:-

$$\% \text{ ERROR} = \frac{(\text{Standard value} \sim \text{Observed Value}) \times 100}{\text{Standard Value}}$$

Precautions:

1. Direct viewing of laser light should be avoided.
2. Proper alignment of the laser diode must be done.
3. Before switching any other source, switch on the laser diode.

Viva-voice

Q1. What is the full form of laser?

Ans. Light amplification by stimulated emission of radiation.

Q2. How laser light is different from the ordinary light

Ans. It is a monochromatic, convergent, coherent and high intense beam of light. While ordinary light is incoherent, divergent and low intense beam of light.

Q3. What is population inversion?

Ans. When the no. of atoms are more in higher energy state than the lower energy state, known as population inversion. it is essential for stimulated emission.

Q4. What is pumping?

Ans. It is process to achieve population inversion.

Q5. What is laser?

Ans. It is a device which is used to convert ordinary light into laser light

Q6. What is meant by the term coherency?

Ans. When the light waves are in same phase and with all most same wavelength in light beam known as coherent.

Q7. What is diffraction?

Ans. When the light bends or deviate from path due to obstacle known as diffraction.

Q8. Define Grating

Ans. It is an arrangement in which there is a fine quality of glass on which parallel lines are ruled equidistant with diamond point by an automatic shifting machine. The ruled lines works as opaque and spacing works as transparent.

Q9. What is active medium?

Ans. it may be solid, liquid, or gas which achieves population inversion.

Q10. What is the action of the optical resonator?

Ans. It is the combination of two reflecting mirror which is used to increase the intensity of laser light.

Experiment No.6

Object:- To draw the characteristic curves of a forward & reverse Biased P-N junction diode and to determine the static resistance of the given diode.

Apparatus Required: Semiconductor P-N junction diode kit and connecting wires.

Theory: A Semiconductor diode is prepared by joining P and N sections of a semi conducting material like germanium or silicon. The P type has excess number of holes while the N type has excess number of electrons. Holes and electrons are respectively the charge carriers in P and N type. They are called the majority carriers. Near about the junction, holes and electrons recombine giving rise to a charge free space called depletion region or barrier region. In this Process, (+)ve charge gets accumulated at the barrier of the N section, and (-)ve charge at the barrier of the P section, creating a potential barrier. A sort of a fictitious battery with it's (+)ve pole on the N section and (–)ve pole on the P section is formed. It is shown in fig. 1. This barrier stops further motion of holes towards N side and electrons towards P side.

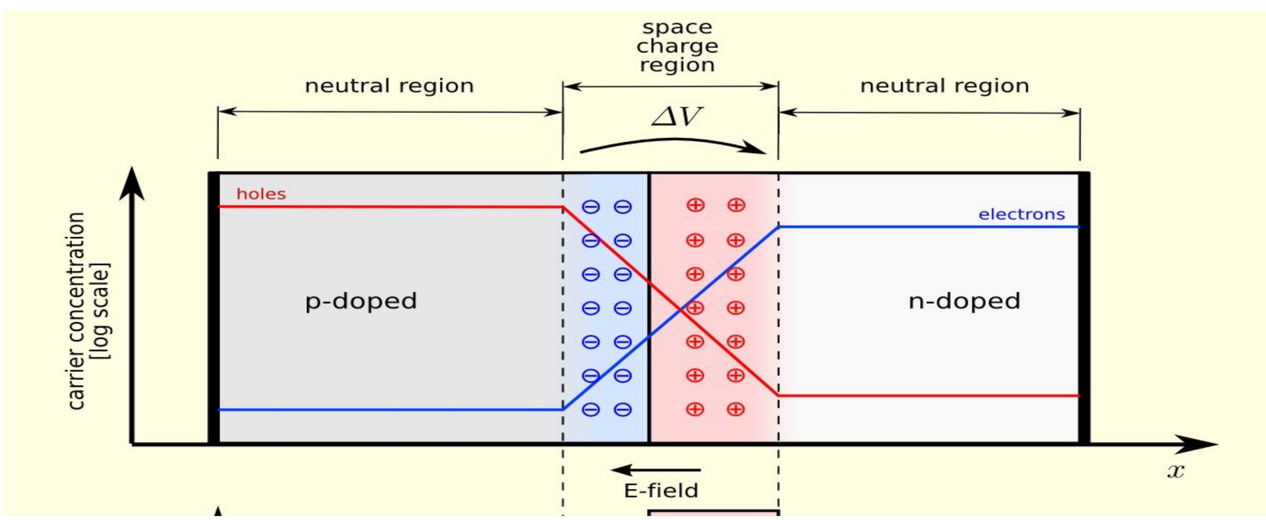


Figure: 1

FORWARD BIASING: When the anode of an external battery is connected to the P side and cathode to the N side, it is called forward biasing. It is shown in fig.(2). When the applied potential is lower than barrier potential, negligible current flow through the junction. As the applied potential higher than that of the barrier potentials, holes would be forced to move towards N side and electrons towards P side. Thus, current starts flowing through the junction in the external circuit. The voltage at which current start increasing called knee voltage. The forward current is increases with the applied potential difference.

REVERSE BIASING: When the anode of an external battery is connected to the N side and the cathode to the P side. It is called reverse biasing. In this case the polarity of the fictitious battery is the same as that of the external battery, as shown fig.(3). Thus, it leads to the increase in the potential barrier, and electron in N type and hole in P type [both majority carriers] are drawn away from the junction, and hence hardly there is any current flowing in the external circuit. However, the small reverse current which flows through the junction is due to minority carriers i.e. electrons in P section and holes in N section. The minority carriers are created due to the action of light and thermal agitation.

If the potential difference in the reverse direction is increased beyond a certain critical limit, the reverse current abruptly increases. This is known as AVALANCHE BREAK DOWN, and the maximum reverse voltage is called Break Down. It is clear from above discussion that a diode offers a negligible resistance when forward biased and a very high resistance when reverse biased.

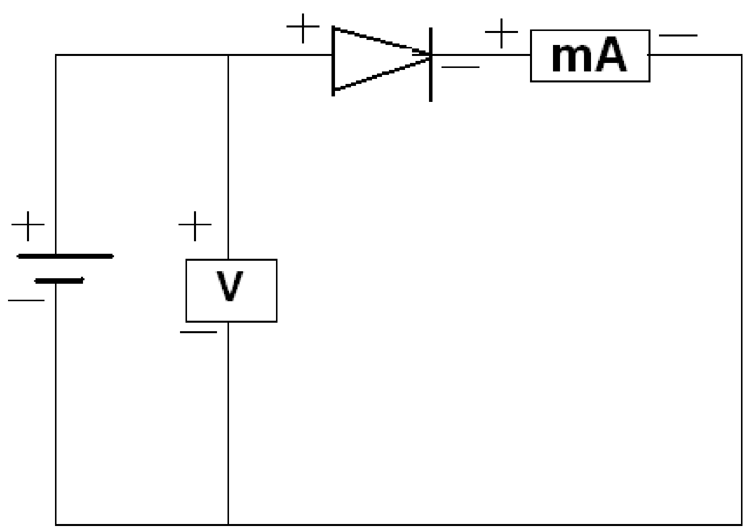
Procedure:

FORWARD BIAS CHARACTERISTICS

Make the circuit according to fig.(2).[use 1V range for voltmeter and 10 mA range for ammeter]

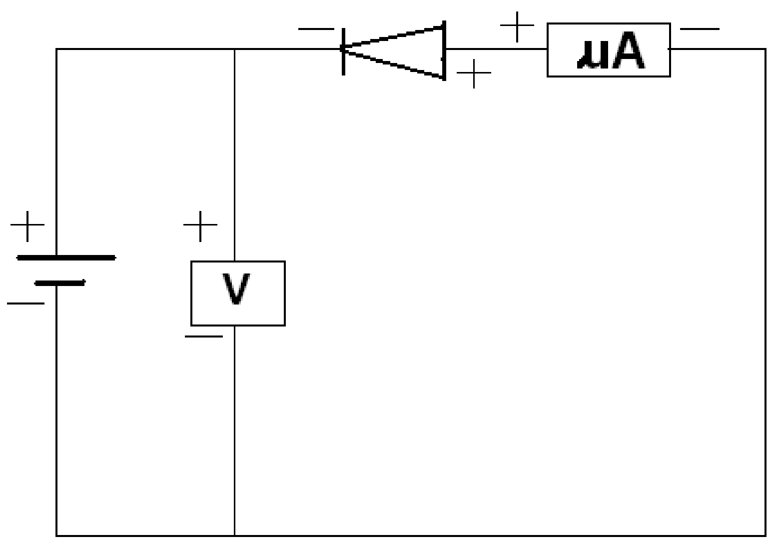
1. By increasing the voltage across the diode in steps of 0.1 volts, note down corresponding current in the table no.1
2. Calculation of static resistance: Using the forward bias curve, take the points on the curve beyond the knee voltage and calculate R

R_{static} = Potential at a point beyond the knee voltage. / Current at that point



REVERSE BIASED CHARACTERRISTICS

1. Make the circuit according to fig.3 [use 10V range for voltmeter and 50 μA range for current meter.]
2. By increasing the voltage across the diode in steps of 1.0 volts, note down corresponding current in the table no 2.



OBSERVATION TABLE-1: FOR FORWARD BIASED

S. No.	Voltage in volts	Current in mA
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

OBSERVATION TABLE -2: FOR REVERSE BIASED

S. No.	Voltage (volts)	Current in μA
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Result:- The I/V Characteristic of P-N Junction diode is shown in the graph.

Precaution and source of error:

1. Voltmeter and ammeter of appropriate ranges should be selected.
2. The variation in V should be done in steps of 0.1 V.
3. The battery connections of p-n junction diode should be checked and it should be ensured that p is connected to positive and n to the negative of the battery.
4. Never cross the limits specified by the manufacturer otherwise the diode will get damaged.

Viva Voce:

Q.1 What is diode?

Ans:A diode is a two-terminal electronic component with asymmetric transfer characteristic, with low (ideally zero) resistance to current in one direction, and high (ideally infinite) resistance in the other.

Q.2 What do you understand by P-N Junction diode?

Ans: A Semiconductor diode is prepared by joining P and N sections of a semi conducting material like germanium or silicon. The P type has excess number of holes while the N type has excess number of electrons. Holes and electrons are respectively the charge carriers in P and N type.

Q.3. Explain forward and reverse biasing in diode?

Ans: When the anode of an external battery is connected to the P side and cathode to the N side, it is called forward biasing. When the anode of an external battery is connected to the N side and the cathode to the P side, It is called reverse biasing.

Q.4. What do you mean by breakdown phenomenon?

Ans: If the potential difference in the reverse direction is increased beyond a certain critical limit, the reverse current abruptly increases. This is known as BREAK DOWN.

Q.5 What is the difference between Zener diode and P-N Junction diode?.

Ans: A P-N Junction diode will let current go in only one direction (forward bias). If current is applied in the opposite direction (reverse bias) then we would not have current on the other end unless the voltage that you apply to it surpasses its Breakdown Voltage, but then diode will be burn out. Zener diodes would act the same way as a P-N Junction diode except that in reverse bias it would allow current to pass when the voltage surpasses its Breakdown Voltage (Zener Voltage).

Q.6 What is the static resistance?

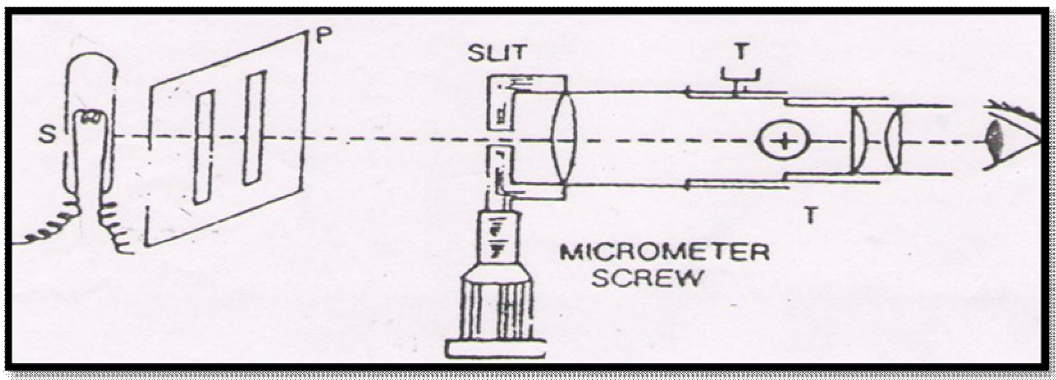
Ans: The static resistance of diode is defined as diode resistance measure when DC voltage is applied above the knee voltage.

Experiment No.7

Object: - To Determination of the Resolving Power of a Telescope.

Required Apparatus:-

Reading Telescope, Attachment of resolving power of the telescope, Number of patterns on glass with stand, Incandescent bulb 40w with house on stand, Inch tape.



Theory and Formula Used:

The theoretical and practical resolving powers are given by

Theoretical resolving power $= \lambda/a$

and practical resolving power $= d/D$

Where λ = mean wavelength of light employed,

a = width of the rectangular slit for just resolution of two objects,

d = separation between two object and

D = distance of the objects from the objective of the telescope.

Hence $\lambda/a = d/D$

Rayleigh's criterion of resolution .According to Rayleigh's criterion, two equally bright sources can be just resolved by any optical system when their distance apart is such that in the diffraction pattern, the maximum due to one falls on the minimum due to the other.

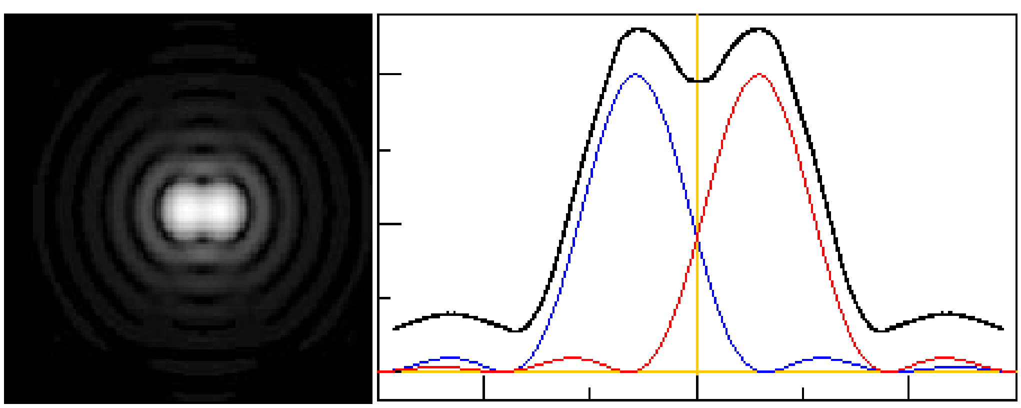
Resolving power of Telescope.

The resolving power of telescope of a telescope may be defined as the inverse of the least angle subtended at the objective by two distant point object which can be just distinguished as separate in its focal plane.

Let a beam of monochromatic light starting from a distant object O (not shown) be incident normally on a rectangular aperture AB fitted in front of the telescope objective .Let AQ represent the incident wave front which is brought to a focus F and observed magnified by means of eyepiece. The intensity pattern at F is shown by thick curved line.

Consider again an object O' towards to right of O whose pattern is formed towards left of the F. The pattern is formed at F' as shown by dotted curve. The wave –front due to the

Incident light is shown by AN. According to the Rayleigh criterion, the two objects can only be resolved when the maximum due to one falls on the minimum due to the other



As the aperture is rectangular the minimum due to one will fall on the maximum of the other when QN = λ. The angle between the two wave fronts, is,

$$\theta = \frac{AQ}{AN} = \frac{\lambda}{a}$$

Where a is aperture and θ is the angle subtended by two objects OO at the objective of telescope.

$$\text{Again} \quad \theta = \frac{OO}{D} = \frac{d}{D} = \frac{\lambda}{a}$$

Where d is the distance between two objects and D is their distance from the objective of telescope.

Procedure:

1. Focus the telescope for clear image far from the telescope.
2. Keep the incandescent bulb (in lieu of sodium lamp we have used incandescent bulb to reduce the cost) in the front of slit pattern
3. Mount the telescope on a stand such that its axis lies horizontal and the rectangular lines in first row marked on pattern board on stand which are vertical. Place the two stands at a suitable distance (say about 2 meters) fig.
4. Illuminate the object with source of light. Now open the slit with the help of micrometer screw and move the telescope in the horizontal direction such that the images of two vertical sources are in the field of view of the eyepiece.
5. Gradually reduce the width of the slit till the two images just cease to appear as two. Note down the reading of the micrometer. Again close the slit completely and note down the micrometer reading. The difference of the two readings gives the width of the slit (a) just sufficient to resolve the two images.

6. Width (d) of white or black rectangular strips in the first row marked on pattern board is one mm.
7. Measure the distance between the object and the slit with the help of inch tape which gives D.
8. The experiment is repeated for different values of D.

Observations: Mean value of $\lambda = 5000 \times 10^{-7}$ mm. d=0.5, 1, 2.5 mm

L.C. of screw = 0.01 mm

S. No.	d mm	Slit Reading						Width of the Slit a = (X – Y)	Distance D mms.
		When Slit is Closed			Slit when Images Cease				
		M.S.	VS	Total X	M.S.	VS	Total Y		
1.	2.5								
2.	1.0								
3.	0.5								

Calculation:

D = distance of the objects from the objective of the telescope.

Theoretical resolving power = λ/a

and practical resolving power = d/D

Where λ = $\lambda = 5000 \times 10^{-7}$ mm.

a = width of the rectangular slit for just resolution of two objects,

d = 2.5, 1.0, 0.5 mms

Hence λ /a = d/D

Result:

The theoretical and practical resolving powers of the telescope are shown in the table.

Theoretical and Practical Resolving Powers:

Distance mm	d mm	Theoretical (λ/a) Resolving Power	Practical (d/D) Resolving Power
	2.5		
	1.0		
	0.5		

Precautions and Sources of Error :

(i) The axis of telescope should be horizontal.

(ii) The rectangular object drawn on the pattern board should be vertical.

(iii) Backlash error in the micrometer screw should be avoided.

(iv) The plane of the slit should be parallel to the objects.

(v) The minimum width of slit for resolution should be adjusted very carefully.

The distance D should be measured from the slit of the telescope to the pattern board.

Viva-Voice

Q.1 What is meant by Resolving Power?

Ans: It is defined as the reciprocal of smallest angle subtended at the objective by two distinct lines (objects) which can be just resolve by the telescope.

Q.2 Why are you saying just resolve?

Ans: Two point sources are resolvable only when the central maxima in diffraction pattern of one falls over the first minimum in the diffraction pattern of the other and vice-verca.

Q.3 Define Reyleigh Criterion?

Ans: According to Reyleigh Criterion, two point sources are resolvable only when the central maxima in diffraction pattern of one falls over the first minimum in the diffraction pattern of the other and vice-verca.

Q.4 What do you mean by diffraction?

Ans: The bending of light wave around the sharp edge of obstacle and spreading into geometrical shadow of obstacle in path of light is called diffraction.

Q.5 On what factor the resolving power of telescope depend?

Ans: Large value of resolving power, we must have large sized aperture a. Thus, the telescope with large diameter of the objective has a higher resolving power.

Q.6 Write to precautions.

Ans: (a) The slit should be clean as edges and narrow.

(b) Telescope, light source and slit pattern should be properly arranged

while taking the observation.

Q.7 What is the relation between resolving power and limit of resolution?

Ans: Resolving Power = 1 / Limit of resolution

Q.8 What is the effect on resolving power, when the pattern board taken far from the telescope?

Ans: Resolving power remain same.

Q.9 Can we increased a resolving power of telescope, if yes than how?

Ans: Yes, by increasing the diameter of objective len

Q.10 Which light is used in the experiment?

Ans: Ordinary light source is used in the experiment.

EXPERIMENT NO. 8

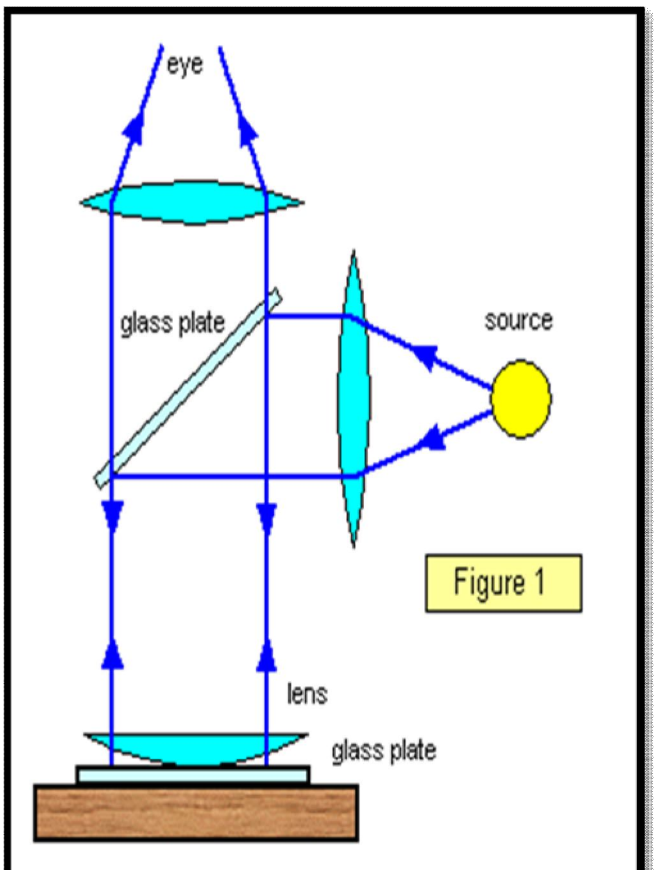
Object: - To determine the wavelength of sodium light by Newton's Ring.

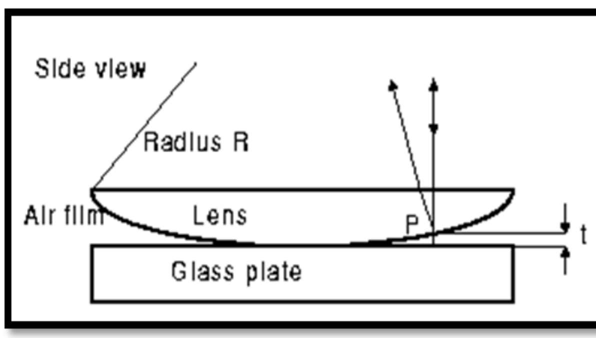
Apparatus: - A Plano-convex lens of large radius of curvature, optically arrangement for Newton's rings, plane glass plate, sodium lamp and traveling microscope.

Theory:

The optical arrangement for Newton's Ring is shown in Fig.(1). A wedge shape air film in formal between Plano-convex lens and glass plate. Interference take place between light reflected from concave surface of lens and upper surface the plate as shown in Fig.(2). In this Experiment the Fringes are of equal thickness i.e. why fringes are circular as shown in Fig.(3).

In this experiment path difference between reflected rays from lens and plate is $\approx 2\mu t$. Locus of points having the same thickness then full on a circle having. Its center at the point of contact. Thus, the thickness of the film is the same at all points on any circle having 0 as the center of the fringes one therefore circular as shown in Fig.(3).





Figure(2)

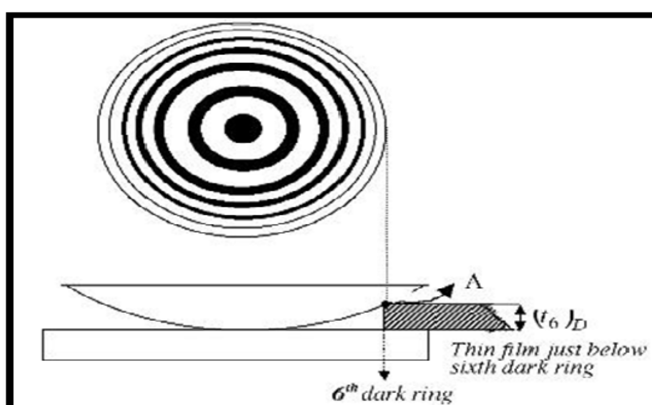


Figure.(3)

Formula used: - The wavelength of Sodium light is given by,

$$\lambda = \frac{D^2{}_{n+p} - D^2{}_n}{4.P.R}$$

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

D_n = Diameter of n^{th} ring.

p = An integer numbers of the ring.

R = Radius of curvature of the curved face of the Plano convex lens.

Procedure: -

1. If a point source is used only then we require a convex lens otherwise using an extended source, the convex lens is not required.
2. Before starting the experiment, the glass platesG1, G2 & the Plano convex should be thoroughly cleaned.
3. The center of lens L2 is well illuminated by adjusting the inclination of glass plate G1 at 45 deg.
4. Focus the eyepiece on the crosswire and move the microscope in the vertical plane by means of rack & pinion arrangement till the rings are quite distinct clamp the microscope in the vertical scale.
5. According to the theory, the center of the interference fringes should be dark but sometimes the center appears white, this is due to the presence of dust particles between glass plate G2 and Plano convex lens L2.in this case lens should be again cleaned.
6. More the microscope in a horizontal direction to one side of the fringes.

   Fix up the cross wire tangent to the ring and note this reading. Again the microscope is moved in the horizontal plane and the crosswire is fixed tangentially to the successive bright fringes noting the vernier reading till the other side is reached.

Observations: -

Least count of the travelling microscope = 0.01mm

Table for determination of [$D^2_{(n+p)} - D^2_n$]

No of rings	Microscope reading		Diameter (a-b) mm	$D^2=(a-b)^2$	$D^2_{n+p} - D^2_n$	Mean mm²	P
	Left end (a) mm.	Right end (b) mm.					
16							
14							
12							
10							
8							
6							
4							
2							

Calculations:-

The wavelength of sodium light is given by-

$$\lambda = \frac{D^2{}_{n+p} - D^2{}_n}{4.P.R}$$

Result: - The mean wavelength of sodium light = --------------------Å

Percentage error

$$\text{\% ERROR} = \frac{\text{(Standard value} \sim \text{Observed Value) X 100}}{\text{Standard Value}}$$

Precautions: -

1. The lens used should be large radius of curvature.
2. Before measuring the diameter of rings the range of the microscope should be properly adjusted.
3. Cross wire should be focused on a bright ring tangentially.

Viva voce

Q.(1). Define Interference.

Ans. Redistribution of energy is called Interference.

Q.(2). What are the types of interference?

Ans. There are two Types of interference

(1)Division of wave front and (2) division of amplitude

Q.(3). On which type of interference does Newton ring based.

Ans. Division of amplitude.

Q.(4.) Which type of light is used in experiment?

Ans. monochromatic source (Sodium light)

Q.(5). Why fringes are circular?

Ans In this experiment fringes are of equal thickness due to the locus of the fringes of equal thickness lies on a circle hence it is circular.

Q.(6). What is the standard wavelength of light used in experiment?

Ans. 5896 A^0

Q.(7).What is the condition for dark central spot?

Ans. At the central spot thickness of film is zero.

Q.(8). What are the uses of this experiment?

Ans. (1) To determine the refractive index of liquid,

(2)To determine the wavelength of light

(3)To determine the radius of curvature of lens.

Q.(9).Which type of lens is used in experiment.

Ans. Plano convex lens

Q.(10). What happened when experiment would be performed by white light.

Ans. A few distinct colored rings be seen

Experiment No. 9

Object: - To determine the Energy Band Gap in a Semiconductor by using a Junction Diode.

Required apparatus:- Semiconductor diode kit, thermometer (0-110^{0}C)

Theory:

A semi-conductor doped or intrinsic always possesses an energy gap between its conduction and valence bands. For conduction of electricity, a certain amount of energy is to be given to the electron, so that it goes from the valence band to the conduction band. This energy so needed is the measure of the energy gap ΔE between the top and bottom of valence and conduction bands respectively. When a P-N junction is reverse biased as shown figure1. the current through the junction is due to minority carriers i.e. due to electrons in P section and holes in N section. The concentration of these carriers depends upon the energy gap ΔE.

For small range of temperature relation we can put as,

$$\log I_s = \text{Constant} - 5.036\ \Delta E\ [10^3/T]$$

Obviously therefore, if a graph is plotted between $\log I_s$ and $10^3/T$, a straight line would be obtained.

Where the slope of this line = $5.036\ \Delta E$

Here ΔE is in electron volts.

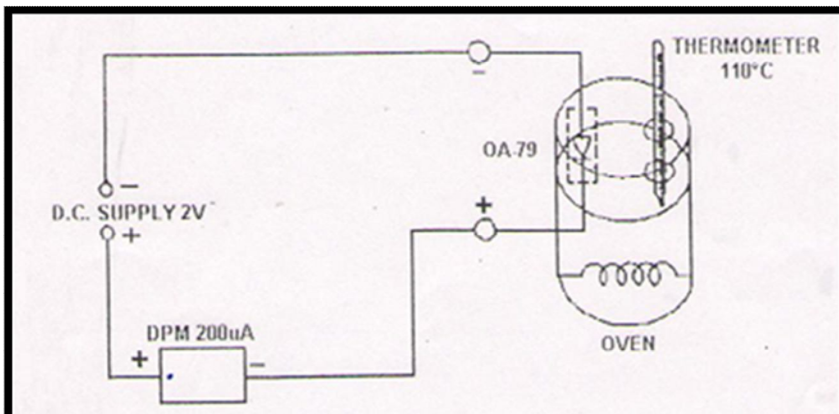


Fig. 1 Experimental Setup

Procedure:

1. Plug the mains lead to the nearest mains socket carrying 230V 10% at 50 Hz A.C.
2. Insert the thermometer and the diode in the holes of the oven (The hole near to the meter is for diode OA- 79).
3. Plug the two leads to the diode in the socket, Red plug in Red socket and Black plug in Black socket.
4. Make the connection as per fig.
5. Now put the power ON/OFF Switch to 'ON' position and see that the jewel light is glowing.
6. Put the 'OVEN' switch 'ON' position and allow the oven temperature T increases up to 80^0C.

Note: When the temperature reaches 80^0C Switch off the oven enabling the temperature to rise further and become stable 80^0C

7. When the temperature becomes stable start taking readings of current and temperature. The current reading should be taken in steps of 5° temperature. The readings should be taken during the fall of temperature from 80^0C downwards.
8. Tabulate your readings in the form shown below:
9. Plot a graph between the readings of $10^3/T$ on x-axis. The graph should come as a straight line cutting both the x-axis and y-axis.
10. Now determine slope of the line.
11. After determining the slope the line calculate the Band Gap as follows:-

$$\Delta E = \frac{\text{Slope of line}}{5.036} \quad = \ \text{.....................eV.}$$

Observations Table:

Temperature in ^{0}C (absolute)	Reverse saturation Current in μA I_s	Temperature T in ^{0}K	$10^3/T$	$Log_{10}I_s$

Determination of Slope through Least Square Fit Method:

$x_i=10^3/T$	$y_i=\log_{10}I_s$	x_iy_i	x_i^2
$\sum x_i$	$\sum y_i$	$\sum x_i y_i$	$\sum x_i^2$

Slope $m = \dfrac{n\sum x_i y_i - \sum x_i \sum y_i}{n\sum x_i^2 - \left(\sum x_i\right)^2}$ and $C = \dfrac{\sum y_i \sum x_i^2 - \sum x_i \sum x_i y_i}{n\sum x_i^2 - \left(\sum x_i\right)^2}$

Percentage Error:-

$$\% \text{ ERROR} = \frac{(\text{Standard value} \sim \text{Observed Value}) \times 100}{\text{Standard Value}}$$

Precautions:-

1. The maximum temperature should not exceed 95^0C
2. Bulb of the thermometer should be inserted well in the oven,
3. Silicon diodes should not be used with the set up as in that case the temperature needed is 125^0C and the oven thermometer provided will not stand to this temperature.

Viva-Voice

Q.1: What is diode?

Ans: The diode consists of two electrodes one is cathode and another is anode. The cathode emits electrons and the anode will attracts the emitted electrons when it is supplied by positive potential.

Q.2: What is energy band gap?

Ans: The gap between the bottom of conduction band and the top of valence band is called Energy gap. To move the electrons from the valence band to conduction band the supplied external voltage must be equal to energy band gap.

Q.3: What is valence band?

Ans: The range of energy which is possessed by valence electrons is known as valence band. Here the electrons which are situated at outer most orbits are called valence electrons. The valence band consists of valence electrons which are having highest energy.

Q.4: What do you mean by conduction band?

Ans: The range of energies possessed by conducting electrons is known as conduction band. The conduction electrons are responsible for the conduction of current in a conducting material. So, these electrons are called as conduction electrons.

Q.5: Classify the solid materials on the basis of energy gap.

Ans: Based on the energy gap the solid materials are classified into 3 types they are: conductors, insulators and semi conductors.

Q.6: Define conductors, insulators and Semi conductors.

Ans: **Conductors:** Those substances whose atoms have their outermost orbits incomplete are known as conductors (e.g. C_u, A_g, A_u etc.). In conductors, valence and conduction bands are found overlapped into each other i.e. the energy gap is zero.

Insulators: Those substances which have large energy gap between their valence and conduction band, are called insulators (e.g. diamond, wood etc.).

Semi conductors: Those substances which have conductivity and resistivity properties in between conductors and insulators are called semi conductors (e.g. Si, Ge). Energy gap of these semiconductors lies between 0.5 to 1.1eV (Foe Ge it is 0.5 – 0.7eV).

Q.7: How many types of semi conductors are there?

Ans: Two types of semi conductors are there (i) Intrinsic or pure semi conductors and

(ii) Extrinsic or impure semi conductors.

Q.8: Define intrinsic and extrinsic semi conductor?

Ans: **Intrinsic semi conductor:** A pure semiconductor is known as intrinsic semi conductor. In these semi conductors, if the temperature increases then the conductivity is also increases. At higher temperatures due to collisions some electrons absorb energy and raises to conduction band then in their places in valence band holes are created. In intrinsic semiconductor number of holes is equal to number of electrons.

Extrinsic semi conductor: A pure semiconductor after doping is called extrinsic or impure semi conductor. Trivalent and penta-valent impurities are added to form P-type and N-type semiconductors respectively.

Q.9: What do you mean by Fermi energy level?

Ans: The level upto which all the energy states are filled by electrons is known as Fermi level. The average energy of charge carriers is calculated by Fermi energy level. In pure semi conductors Fermi energy level is at the centre of the valence and conduction bands. In extrinsic/impure P-type (N-type) semiconductor Fermi energy level is near to the valence (conduction) band.

Q.10: Define Doping and Dopant?

Ans: The process of adding impurities to a pure semi conductor is called doping

The material added as impurity is called as Dopant.

Q.11: What are P-type and N-type semi conductors?

Ans: If we add trivalent impurities such as Aluminum to a pure semi conductor then the material is called P-type semi conductor. If a pentavalent impurity such as Arsenic is added to a pure semi conductor then the material is called N-type semi conductor

Q.12: Why P-type (N-type) semi conductor is called Acceptor (Donor)?

Ans: In P-type material 3 electrons of trivalent atom makes covalent bonds with Semiconductors such as Si or Ge and there is a need of one more electron to make the system stable because Si or Ge has 4 electrons in their outermost orbits. For this reason P-type material is also known as Acceptor.

On the other hand, in case of N-type of material 4 electrons of pentavalent atom makes covalent bonds with Semiconductors such as Si or Ge which have 4 electrons in their outermost orbits and hence there is one free or excess electron remains present in the structure. For this reason N-type material is also known as Donor.

Q.13: What is P-N junction diode?

Ans: If P-type and N-type semi conductors are combined to each other then the resultant structure is called P-N junction diode. This means if trivalent impurity is doped to one end of the pure semi conductor and pentavalent impurity to other end, a P-N junction diode can be formed.

Q.14: What do you mean by Forward Biasing?

Ans: When a battery's positive terminal is connected to P-type material and battery's negative terminal is connected to N-type material of a P-N junction diode, then this mode of operation is said to be in forward biasing. Here the holes of P are repelled by the positive terminal of the battery and electrons of N are repelled by the negative terminal of the battery and hence both holes and electrons moves towards the junction. As the applied voltage becomes large enough to destroy the depletion barrier diode starts conducting. This Forward Biasing is also called as Low resistance connection. In this mode of biasing the current flow is mainly due to majority charge carriers.

Q.15: What do you mean by Reverse Biasing?

Ans: When a battery's positive terminal is connected to N-type material and battery's negative terminal is connected to P-type material of a P-N junction diode, then this mode of operation is said to be in forward biasing. Here the holes of P are attracted by the negative polarity of the battery and electrons of N are attracted by the positive polarity of the battery and hence both holes and electrons move away from the junction and then this increases the width of depletion layer. This reverse Biasing is also called as High resistance connection. In this bias the current is mainly due to minority charge carriers. In this mode, very small current flows across the junction.

Derivation of the formula used:

When PN junction is placed in reverse bias, the current flows through the junction due to minority charge carriers. The concentration of these charge carriers depend on band gap E_g. The saturation value I_s of reverse current depends on the temperature of junction diode and it is given by following equation

$$I_s = A\left[N_n e v_n + N_p e v_p\right] e^{\frac{-E_g}{kT}}$$

Where, Nn (Np) is the concentration of electrons (holes) in N(P)-type region

v_n and v_p are the drift velocities of electrons and holes respectively

A is the area of junction, k = 1.38 x 10^{-23} J/K, is Boltzman's constant and T is absolute temperature of junction.

Taking log of both the sides of above equation, we have

$$\log_e I_s = \log_e A\left[N_n e v_n + N_p e v_p\right] - \frac{E_g}{kT}$$

As $\log_e x = 2.3026 \log_{10} x$

Therefore, $2.3026 \log_{10} I_s = 2.3026 \log_e A\left[N_n e v_n + N_p e v_p\right] - \frac{E_g}{kT}$

Or $\log_{10} I_s = C - \frac{E_g}{2.3026 kT}$; where C is a constant which is equal to the first term of RHS of above equation.

On substituting the value of k and converting the unit of E_g, we get

$$\log_{10} I_s = C - \frac{1.6\times10^{-19} E_g}{2.3026\times1.38\times10^{-23} T}$$

$$\log_{10} I_s = C - \frac{5.036\times10^{3} E_g}{T}$$

$$\log_{10} I_s = C + (-5.036 E_g)\times\frac{10^3}{T}$$

This represents a straight line having a negative slope (5.036Eg). Therefore, by knowing the slope of the line, E_g can be determined through following formula

$$Slope = 5.036 E_g$$

E_g= Slope of the graph (straight line) drawn between $\log_{10} I_s$ and $(10^3/T)/5.036$ = ...eV.

EXPERIMENT NO. 10

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

Apparatus Required: Diode Laser Source, Fiber Holders, Optical Fiber, and Base With Rotational Mount, Holders And Bases.

Theory: Numerical aperture is a basic descriptive characteristic of a specific fiber. It represents the size or degree of openness of the input acceptance cone. Mathematically it is defined as the sine half angle of the acceptance cone.

Using snell's law, the maxima angle with in which light will be accepted into and guided through fiber is

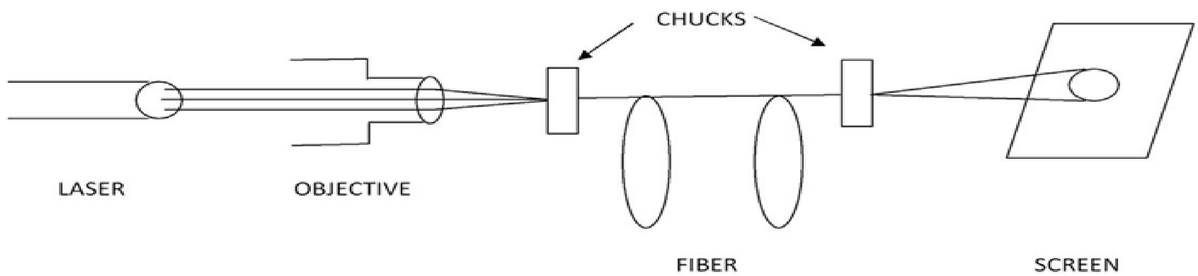
$$NA = \mathrm{Sin}(\theta_a) = (n_1^2 - n_2^2)^{1/2}$$

Where θ_a is the numerical aperture and n_1 and n_2 are the refractive indices of the core and the cladding. If the incident angle $\theta < \theta_a$, the ray undergoes multiple internal reflections at core and cladding interface and it is called the guided ray. If $\theta_a < \theta$, the ray undergoes only partial reflection at core cladding interface.

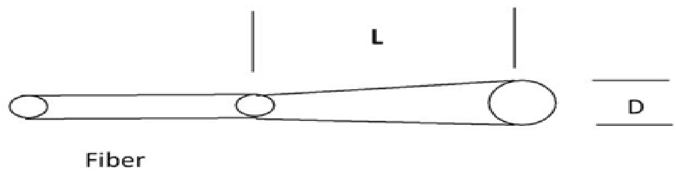
In short length of straight fiber, ideally a ray launched at angle θ at the input end should come out at the same angle θ from output end. Therefore, the far field at the output end will also appear as a cone of semi angle θ_a emanating from the fiber end.

Procedure:

1. Mount Laser source, objective and detector on the respective holders.
2. Mount both the ends of the optical fiber on the fiber holders.
3. Align the difference objects as per the setup shown below.
4. Couple the light from the laser source onto one of the fiber ends using a microscopic objective (provided with the kit).
5. Place the screen (sheet having circular markings) at some distance from the output end of the fiber such that it is perpendicular to the axis of the fiber. Now move the screen towards or away from the output end of the fiber such that circular beam emanating from the fiber end covers the (1^{st} or 2^{nd} or 3^{rd}) circle on the screen.



Experimental Setup



6. Measure the distance between the output end of optical fiber and screen. Let this be L, also measure the diameter of the circular spot formed on the screen. (Diameter is mentioned in mm). Let it be D.
7. Use the formula

$$NA = Sin\left[\tan^{-1}\left(\frac{D}{2L}\right)\right]$$

<u>Observations table:</u>

S.No.	Diameter of Laser Spot **D mm**	Distance between Optical Fiber and Screen **L mm**	$\frac{D}{2\ L}$	$\theta = \left[\tan^{-1}\left(\frac{D}{2L}\right)\right]$	Sin θ

Result:

Numerical Aperture of given optical fiber is=……………………………………

Percentage Error:-

$$\% \text{ ERROR} = \frac{\text{(Standard value} \sim \text{Observed Value)} \times 100}{\text{Standard Value}}$$

Precautions:

1. Reading should be taken carefully.
2. Direct viewing of laser light should be avoided.
3. Laser light should be incident normally on the Screen.

Viva voce

1. Define optical fiber.

   Ans. It is a cable which carries optical signal.

2. On which phenomenon light propagation take place in optical fiber

   Ans. Total internal reflection.

3. What is total internal reflection?

   Ans. When light travels from denser medium to rarer medium and angle of incidence is greater than critical angle then light reflects back into same medium this phenomenon is called Total internal reflection.

4. Define angle of acceptance

   Ans. Angle at which light enter into optical fiber and Total Internal Reflection takes place.

5. What is physical significance of numerical aperture.

   Ans. Light gathering ability of the fiber.

6. What are the types of optical fiber

Ans. There are two types of fiber (1) step index fiber (2) graded index fiber.

7. What is fractional refractive index?

Ans. It is the ratio of difference of the refractive indices of core and cladding to the refractive index of core i.e.,

$$\Delta = \frac{n_1 - n_2}{n_1}$$

8. Which light source is used in experiment

Ans. Diode Laser

9. LASER stands for what?

Ans. Light Amplification by Stimulated Emission of Radiation

10. How many type of fiber losses are there?

There are three types of fiber losses

(1) Absorption
(2) Rayleigh Scattering
(3) Geometrical losses

Experiment No.-11

Object:- To verify Inverse square law of light using a photo cell.

Apparatus Required:- Optical bench, Photocell housed with Red and Black sockets, lamp house with lamps, DC Microammeter.

Theory:- The Photoelectric emission may be regarded as a phenomena of liberation of an electron at the surface of a metal when a photon of light having energy above threshold energy (metal work function) incident on a metallic surface and transfer the enough energy to the electron to escape through the potential barrier layer. The photo cell can be considered as the generation of a voltage across a circuit element under illumination.

Let P be the illuminating Power of a source so the intensity of illumination I due to it at a distance r would be

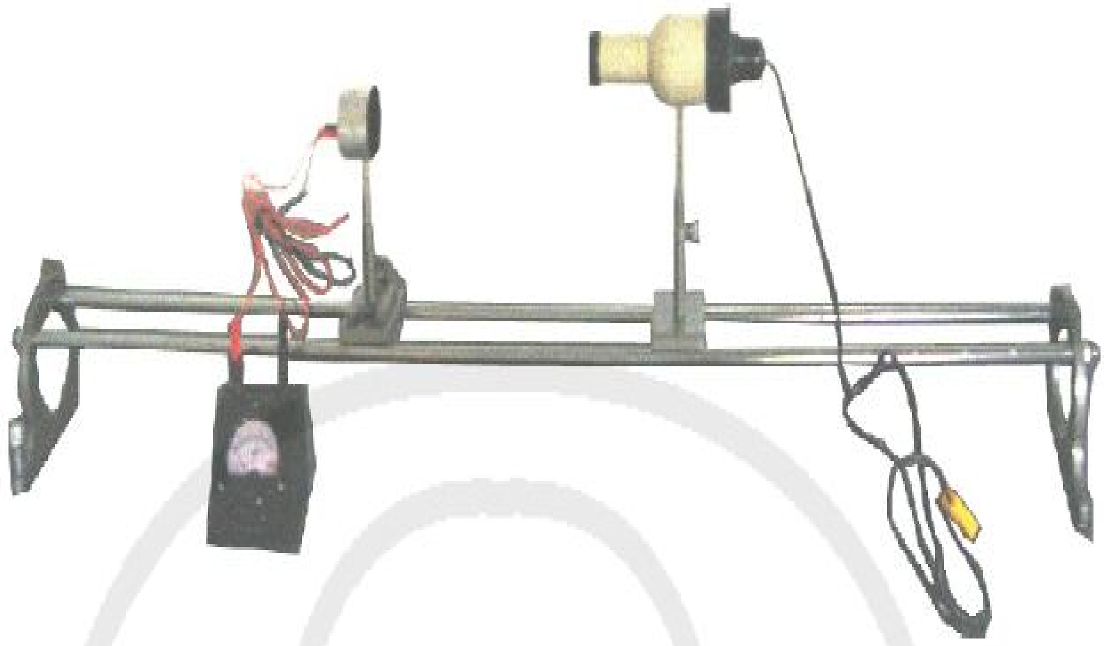
$$I = P/r^2$$

Since the photo electric current (θp) produced is directly proportional to the intensity of illumination ie.

$$I \propto \theta p$$

$$I = K\theta p$$

Where K is constant, hence $I = P/r^2 = K\theta p$. Since P and K are constant hence the relationship between $1/r^2$ and θp is straight line which verifies the inverse square law of radiation.



Procedure:-

1. Arrange the optical bench in such a way that both the lamp and the photo cell are at the same level as shown in the figure.
2. Make the connection of photo cell to microammeter Red to (+)ve and black to (–)ve terminal of the microammeter.
3. Adjust the distance of the lamp such that we will get the microammeter reading
4. Then decreases the distance in step of 5cm and each time note the reading in microammeter and note your observation in table-1.
5. Draw the curve between $1/r^2$ and d. $1/r^2$ on x axis and θp at y axis.

Observation table:-

S.N.	Distance of lamp from cell in cm 'r'	$1/r^2$	Reading in microammeter (θp) uA
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

Result:-

The graph between θp and $1/r^2$ is a straight line. It show that microammeter reading is inversely proportional to the square of the distance from the source. but deflection is directly proportional to the intensity of illumination of the surface. Hence we can say that intensity of illumination varies inversely square of the distance from the source. Thus inverse square law is verified.

Precautions:

1. Light should fall on normally on the photocell

2. The photocell should not be exposed to light for a long time continuously.

3. A Cover should be placed on the photocell to protect it.

Viva Voce:

Q.1 What is photoelectric effect?

Ans: When light is falls on metal surface, an electron is emitted from a metal if the energy of the photon is greater than the work function of the metal.

Q.2 What is the photo cell?

Ans: A photocell is a type of resistor. When light strikes the cell, it allows current to flow more freely. When dark, its resistance increases dramatically.

Q.3: Does the photo electric current depend on frequency of light and intensity of light? How?

Ans: The photons of a light beam have a characteristic energy proportional to the frequency of the light. In the photoemission process, if an electron within some material absorbs the energy of one photon and acquires more energy than the work function (the electron binding energy) of the material, it is ejected. If the photon energy (Frequency) is too low, the electron is unable to escape the material. Increasing the intensity of the light beam increases the number of photons in the light beam, and thus increases the number of electrons excited, but does not increase the energy that each electron possesses. The energy of the emitted electrons does not depend on the intensity of the incoming light, but only on the energy or frequency of the individual photons. It is an interaction between the incident photon and the outermost electron.

Q.4: Define the illuminating power, Intensity of illumination?

Ans: Illumination power is defined as the intensity per unit area. Intensity is defined as no. of photon incident per unit area.

Q.5:Explain the construction of photo cell?

Ans: This is Selenium Photocell. This consist of metal base plate mainly Aluminum, steel or brass. On This base plate a very thin layer of special grade selenium is deposited followed by a deposition of light transparent protective film of cadmium or cadmium Oxide. The light sensitive face of a selenium photocell is either brown or bluish brown in appearance and has a narrow silvery collector strip. This strip serves as a negative terminal. The back of base plate is also coated with the same material as the narrow strip and serves as a positive terminal.