D Y Patil University

Ramrao Adik Institute of Technology

LAB MANUAL

Engineering Physics

List of Experiments

Sr. No.	Name of Experiment
1	Newton's Rings :Determination of radius of curvature of a Plano- convex lens
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4	Optical fibre : Determination of Numerical aperture
5	Determination of Planck's constant 'h' using LED.
6	Energy Band Gap of Semiconductor
7	Hall Effect: Determination of Hall coefficient and Carrier Concentration.
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10	Virtual Lab

Name of the Student:	
Division:	
Roll No.:	

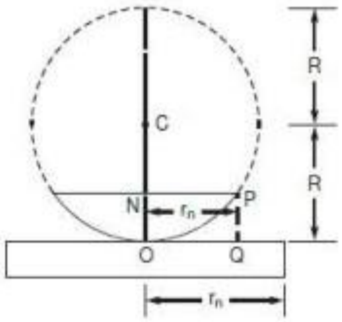
Experiment 1

1. **Aim:** To measure the radius of curvature of Plano convex lens using Newton's rings set up.

CO1	Study of Newton's rings by the technique of division of amplitude in thin film interference.

2. **Apparatus:** Travelling microscope, Plano convex lens of large radius of curvature, glass plates, Lamp on stand, sodium vapour lamp, and magnifying lens.

3. **Theory:**
A Plano convex lens of large radius of curvature is placed on a clean glass plate (optically flat) and viewed in monochromatic light, a series of rings may be seen around the point of contact between the lens and the slide. These rings are known as Newton's rings and they arise due to the interference of light reflected from the upper surface of glass plate of the air film and lower surface of lens. Under reflected system the interference pattern is alternate dark and bright concentric circles, with centre dark spot.



Suppose the radius of curvature of the lens is R and the thickness of the air film is t at distance OQ = r, from the point of contact O. The effective path difference between the interfering rays is

$$\Delta = 2\mu t\cos r \pm \frac{\lambda}{2}$$

The condition for constructive and destructive interferences are given as; for normal incidence **cos r = 1** and for air film **μ = 1.**

For constructive interference $$2t = (2m+1)\frac{\lambda}{2}$$

For destructive interference $$2t = m\lambda$$

The thickness of the thin film in terms of any dark or bright ring is given by

$$2t = \frac{r_m^2}{R}$$

Central dark spot: At the point of contact of the lens with the glass plate the thickness of the air film is very small compared to the wavelength of light therefore the path difference introduced between the interfering waves is zero. Consequently, the interfering waves at the centre are opposite in phase and interfere destructively. Thus a dark spot is produced.

Circular fringes with equal thickness: Each maximum or minimum is a locus of constant film thickness. Since the locus of points having the same thickness fall on a circle having its centre at the point of contact, the fringes are circular.

1. Radii of the mth dark rings:

$$r_m = \sqrt{m\lambda R}$$

2. Radii of the mth bright ring:

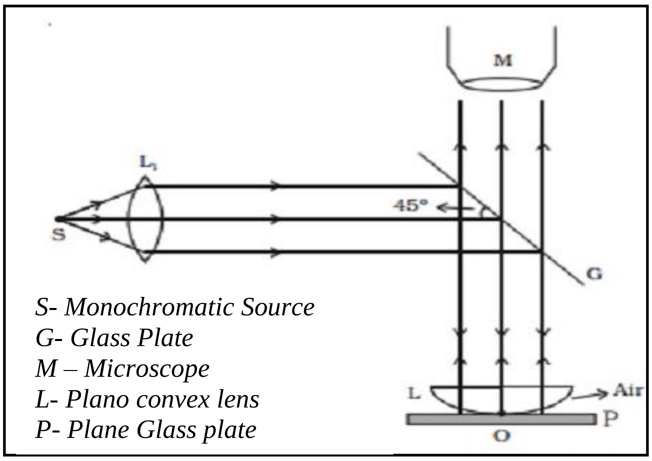
$$r_m = \sqrt{(2m+1)R\frac{\lambda}{2}}$$

The wavelength of monochromatic light can be determined as,

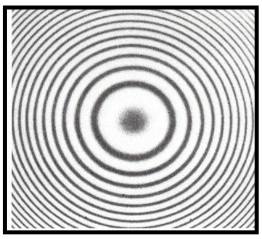
$$\lambda = \frac{D_{m+n}^2 - D_n^2}{4mR}$$

Where, D_{m+n} is the diameter of the $(m+n)^{th}$ dark ring and D_n is the diameter of the n^{th} dark ring.

Diagrams:



Experimental Set up



Reflected System

4. **Procedure:**
   1. Illuminate the Newton's ring set up with monochromatic Sodium light.
   2. View the light reflected from air film through eyepiece of the travelling microscope. Observe the interference pattern which contains concentric circular dark and bright rings with centre dark spot.
   3. Bring cross wire towards left 10th dark ring, note the reading.
   4. Shift the cross wire towards 10th, 8th, 6th, 4th , 2nd on L.H.S. Similarly move towards 2nd, 4th, 6th, 8th and 10th on R. H. S. Accordingly note the readings.
   5. The difference between LHS and RHS readings give the diameter of particular order of any dark ring.

Observations:

Least Count of Travelling Microscope = ...mm

Wavelength of Sodium light = λ = 5893 Å = 5893 × 10^{-7} mm

Sr. No.	**Dark ring no.**	**Microscope reading (mm)**		**Diameter D (mm)**	**D^2 (mm^2)**	**$(D_{m+n})^2 - (D_n)^2$ (mm^2)**
		L.H.S.	**R.H.S.**			
1.	10					
2.	8					
3.	6					
4.	4					
5.	2					
						Avg =

Formula: Radius of curvature,

$$\textbf{R by calculation} = \frac{(D_{m+n})^2 - (D_n)^2}{4m\lambda} \qquad m=2$$

R=

6. Result

1. Radius of curvature of Plano convex lens, R =........ mm =.........m by calculation

7. Conclusion and Discussion:

Central Spot is dark in reflected light due to phase inversion of reflected ray (Stoke's law) and Rings come closer and become thinner with increasing order.

8. QUIZ / Viva Questions:

1) What change in the pattern will be seen if monochromatic light is replaced by white light?
2) How one can get bright spot at the centre of pattern in reflected system?
3) What happens if air film is replaced by water?

Experiment 2

LASER: Determination of divergence of Laser beam and thickness of human hair.

1. **Aim:** To calculate the beam divergence of laser beams and estimate thickness of human hair.

2. **What will you learn by performing this experiment?**
   Student will learn to understand property of laser beam and also learn to apply laser to find out dimension of small objects.

3. **Apparatus:** He-Ne gas Laser, Power supply, scale, micrometer screw gauge and Human hair.

4. **Theory:**
   1. Divergence of laser beam is given by,

$$\emptyset = \frac{d_{m+n} - d_m}{D_{m+n} - D_m}$$

Where, d_m is diameter of laser spot for D_m distance between screen and laser.

2. Thickness of human hair is calculated by maxima in diffraction due to single slit,
i.e.

$$a \sin\theta = m\lambda$$

Thickness of hair is

$$a = m\lambda/sin\theta$$

But for smaller θ

$sin\theta = \tan\theta = \theta$
So,

$$a = m\lambda/\theta$$

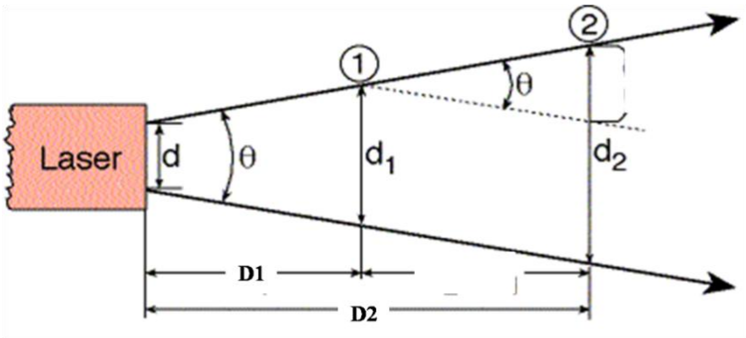
But $\theta = x/2D$ where x is distance between m^{th} order spots

D is distance between hair and screen.

So, Thickness of hair is

$$a = 2m\lambda D/x$$

5. Diagram:



Divergence of Laser beam

6. Procedure:

For Divergence of Laser:

1. Measure distance between screen and Laser (D_m).
2. Hold piece of paper on screen and incident laser beam on it.
3. Trace Laser spot on paper and measure its average diameter (d_m).
4. Repeat the same process by varying distance between screen and laser.
5. Calculate angle of divergence with given formula.

For Measurement of thickness of human hair:

1. Set up the laser and Human hair in order to get diffraction pattern.
2. Measure the distance D between the Screen and the human hair.
3. Measure the distance *x* between the m^{th} order spots appearing on the left and right sides of the center bright spot (principal maxima).
4. Calculate thickness of the hair with given formula.

7. Observation Table

Wavelength of He-Ne Laser $\lambda = 6328$ Å

1. Divergence of Laser beam:

Sr. No.	Distance between Screen and Laser (D_m) in cm	Spot Size (d_m) in cm	Divergence (ϕ)
1			
2			
3			
4			
5			

2. Thickness of human hair:

Sr. No.	Distance between hair and screen (D) in cm	Diffraction Order (m)	Distance between m^{th} order spots (x) in cm	Thickness of hair **a= 2mλD/*x*** in µm	Average Thickness in µm
1.		m=1			
		m=2			
		m=3			
		m=4			

8. Calculations:

9. Result and Conclusion:

1. Divergence of LASER Beam:

2. Thickness of Human Hair:

Signature of Faculty

Experiment 3

1. **Aim:** To determine wavelength of LASER using diffraction grating.

2. **What will you learn by performing this experiment?**
One will understand that order of the spectrum and resolution of the grating depends on the number of lines on the grating.

3. **Apparatus:** He-Ne gas Laser, Power supply, Plane diffraction grating, and Scale.

4. **Theory:**
A **LASER** is a device that emits light through a process of optical amplification based on the stimulated emission of electromagnetic radiation. The term "**LASER**" originated as an acronym for "light amplification by stimulated emission of radiation".

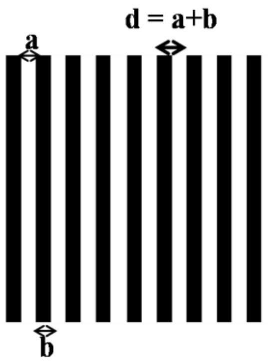
Spontaneous emission is the process in which a quantum mechanical system such as an atom, molecule or subatomic particles makes transitions from an excited energy state to a lower energy state and emits energy (quantum) in the form of a photon. It is natural, and uncontrolled process and emitted radiations are incoherent (random) in nature. e.g. LED, Sunlight, Sodium Lamp etc.

Stimulated emission is the process by which spontaneously generated photon or external incident photon of a specific frequency interacts with an excited atom, causing it to drop to a lower energy level and release photon identical to incident photon. It is controlled process and radiations are highly coherent, directional and monochromatic in nature. e. g. MASER and LASER.

He-Ne Laser: The He-Ne LASER consists of a mixture of He and Ne of about 10:1 placed inside a long narrow discharges tube. The pressure inside the tube is about 1mm of Hg. The gas system is enclosed between a set of plane mirrors or set of convex mirrors so that a resonator system is formed. One of the mirrors is of very high reflectivity while the order is partially transparent so that energy can be compelled out of the system.

DIFFRACTION GRATING:

An arrangement consisting of a larger number of parallel slits of the same width, separated by equal opaque spaces is known as DIFFRACTION GRATING. When a Wave front is incident on a grating surface; light is transmitted through these slits but obstructed by opaque spaces. Such a grating is called transmission grating. There is another type of grating called as refection grating.



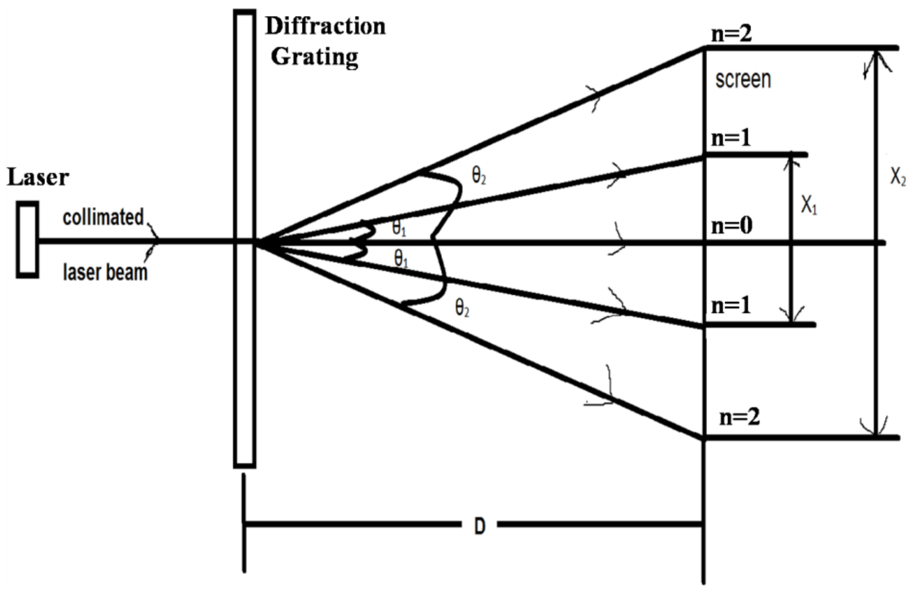
Plane Diffraction Grating

In this type the lines are drawn from the position of the mirror in between any two lines. In general, the path difference is

$$\mathbf{(a + b) \sin \theta = m \lambda,}$$

$$\mathbf{\lambda = (a + b) \sin \theta / m.} \text{ where } a+b = d \text{ (grating element)}$$

Diagram:



Observation: The number of lines per mm on the grating, N = 300 lines / mm

Hence, grating element, d= a+b = 1 / N =...1/300........mm

Observation Table:

(Write down values of diffraction angle up to two decimal points and sin, tan up to four decimal points.)

Sr. No.	Distance between the grating element and screen' D' (cm)	Order of diffraction 'm'	Distance between m^{th} order spots 'X'(cm)	$\tan\theta = X/2D$	θ (deg)	$\sin\theta$	$\lambda = \frac{d \sin\theta}{m}$ (Å)
1							
2							
3							
						Mean λ =	

5. **Procedure:**
   1) Set up the laser and grating as shown in figure.
   2) Measure the distance D between the Screen and the diffraction grating.
   3) Turn on the laser and center the meter stick at the 0^{th} order image on the screen.
   4) Measure the distance X1 between the 1^{st} order images appearing on the left and right sides of the center line.
   5) Measure the distance X2 between the 2^{nd} order images appearing on the left and right sides of the center line.

6. **Calculation:**

   Wavelength of Laser source is given by,

$$\lambda = \frac{d \sin\theta}{m}$$

7. **Result**: Average Wavelength of laser beam, λ = ...mm =________________ Å.

8. **Conclusion and Discussion:**

The given source of light is highly monochromatic and coherent in nature.

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9. **QUIZ / Viva Questions:**
10.

1) What do you mean by diffraction? Why don't we observe diffraction of sound in daily life?
2) How Young's double slit interference differ from double slit diffraction in terms of dimensions and wavelength?
3) How separation between the spectral lines will be increased in diffraction pattern obtained in white light using diffraction grating?

Experiment 4

1. **Aim:** To determine the numerical aperture of the given optical fibre

2. **What will you learn by performing this experiment?**
   One will understand that optical fiber is used for fastest and secured data communication in transmission system.

3. **Apparatus:** Fibre optic kit, N.A. Measurement jig, 1m optical fibre.

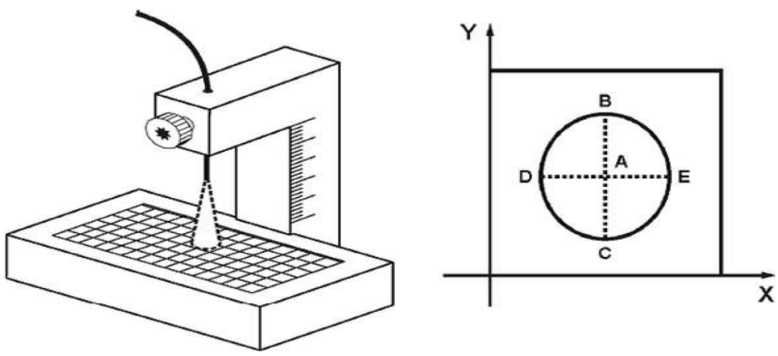
4. **Theory:**
   1) An optical fibre (or optical fibre) is a flexible, transparent fibre made by drawing glass (silica) or plastic to a diameter slightly thicker than that of a human hair.
   2) Optical fibres typically include a transparent core surrounded by a transparent cladding material with lower refractive index (R. I.). Light is kept in the core by the phenomenon of total internal reflection which causes the fibre to act as a waveguide.
   3) Optical fibres are used most often as a means to transmit light between the two ends of the fibre and find wide usage in fibre-optic communications, where they permit transmission over longer distances and at higher bandwidths (data rates) than wire cables

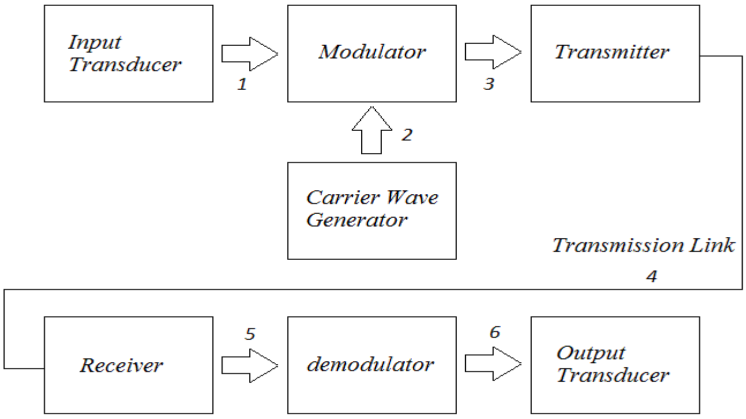
   Numerical aperture (N. A.) parameter provides maximum light handling capacity of the optical fibre. It refers to the maximum angle (acceptance angle) at which the light incident on the fibre end is totally internally reflected and is transmitted properly along the fibre.

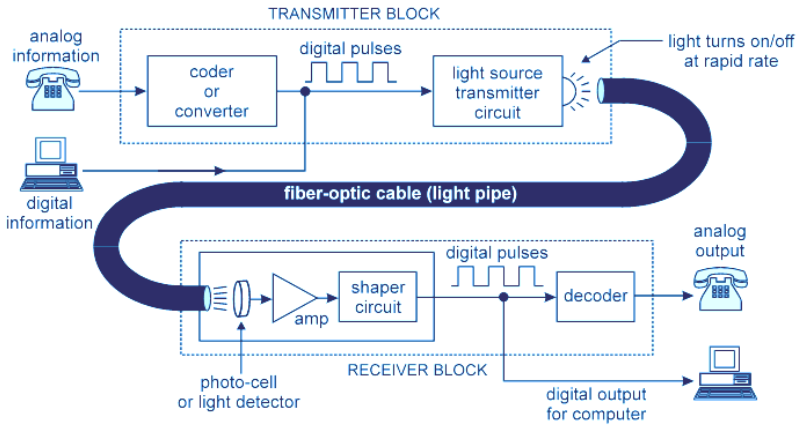
   This is given by:

$$\boldsymbol{N.A. = Sin(i_{max})}$$

Diagram:







Optical Fiber communication system

5. Procedure: :

4) Connect the optical fibre to kit.

5) Connect the power supply to kit and switch it ‘On’, observe a glow at the other end of the fibre.

6) Insert the other end of the optical fibre into the N.A. measurement jig.

7) Light should fall normally on the white sheet.

8) Observe the illuminated circular path of light on the sheet.

9) Measure the distance between the sheet and the fibre exactly (‘a’ cm).

10) Calculate the mean radius (‘r’ cm) of the illuminated patch.

11) Determine the value of Numerical Aperture (N.A.) and Acceptance angle (i_{max}).

Observation Table:

Sr. No.	Distance between Fiber tip and Screen "a" (cm)	Radius of the Circular Spot "r" (cm)	Acceptance Angle i_{max} (degree)	Numerical Aperture (N. A.)
1.				
2.				
3.				

6. Calculations:-

$$\tan(i_{max}) = \frac{r}{a}$$

$$i_{max} = tan^{-1}\left(\frac{r}{a}\right)$$

$$N.A. = Sin(i_{max})$$

7. Results:

1. Maximum angle of incidence, i_{max} = ------------ degree
2. Average N.A. of the given fiber is = ------------

8. Conclusion and Discussion:

Numerical aperture of given fibre is greater than 0.2, therefore fibre is MMF.

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9. QUIZ / Viva Questions:

1) What do you mean by total internal reflection? How it works in Optical fibres?
2) How acceptance angle and critical angle are related?
3) Explain basic optical fibre communication system?
4) What are the demerits of optical fibre communication system?

Experiment 5

1. **Aim:** Determination of Planck's constant using Light Emitting Diode (LED).

2. **What will you learn by performing this experiment?**
Student will understand that according to quantum mechanics, energy radiation is in the form of wave packet and energy of the radiation depends on frequency.

3. **Apparatus:** Different colours LEDs, Power supply, mili Voltmeter, mili Ammeter and connecting wires.

4. **Theory:**
Planck's constant:
The Radiation energy emitted or absorbed is discontinuous (discrete) and it is in the form of quantum (energy packet). Planck's constant is the fundamental constant in modern physics. It relates the energy of a photon to its frequency.

$$E = h\gamma$$

Where, E is the energy of photon, h is the Planck's constant and γ is the frequency of the emitted photons. When the diode first emits light the voltage across the diode, V_0, is just enough to give energy to electrons to jump from valance band to conduction band. Therefore

$$E = eV_0 = h\gamma = \frac{hc}{\lambda}$$

Where e is the electron charge and V_0 is the threshold voltage.
LED (Light Emitting Diode):
A light-emitting diode (LED) is a p–n junction diode (made up form direct band gap semiconductor such as GaAs, GaP and GaN) emits light in forward bias. When a suitable voltage is applied to junction, electrons are able to recombine with holes within the device, releasing energy in the form of photons. The output from an LED can range from red (at a wavelength of approximately 700 nanometers) to blue-violet (about 400 nanometers)
Conventional LEDs are made from a variety of inorganic semiconductor materials, producing the following colours:
   1. Aluminium gallium arsenide (AlGaAs) — red and infrared
   2. Aluminium gallium phosphide (AlGaP) — green
   3. Gallium arsenide phosphide (GaAsP) — red, orange-red, orange, and yellow
   4. Gallium phosphide(GaP) — red, yellow and green

5. **Procedure:**

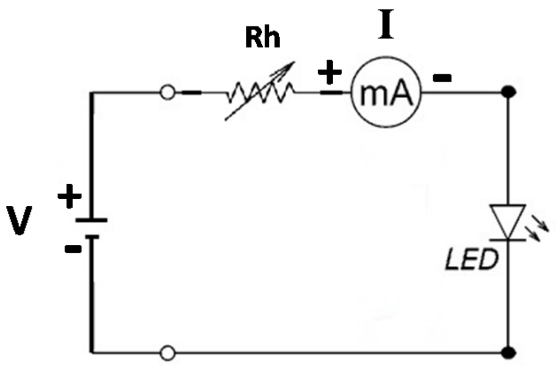
1. Make the connection on experimental kit as shown in circuit diagram.
2. Set the range of DC voltmeter at 20 mV and switch ‘On’ the power supply.
3. Now vary the DC voltage slowly by variable resistance pot and note current readings.
4. Now switch ‘Off’ the DC power supply and break the LED connection.
5. Again make same connection for another colour of LED.
6. Now repeat the above steps for different LEDS.
7. Repeat above experiment for different colours of LEDs.
8. Plot I-V characteristics for different LEDs and find out threshold voltage V_0.
9. Now use the formula given below and put the value of all parameters used in formula and calculate the value of Planck's constant for different LEDs.

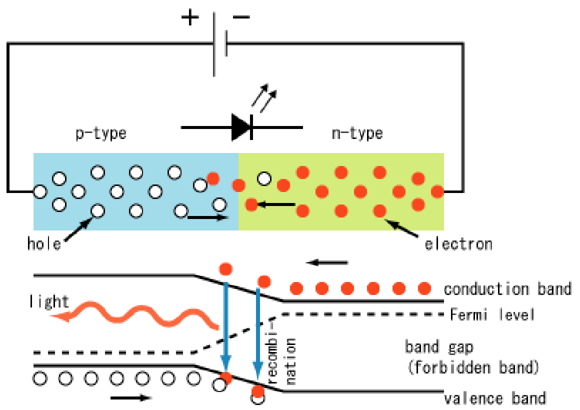
E= h f=eVo=hc/ λ

$$h = \frac{eV_0\lambda}{c}$$

10. Take mean value of h calculated for different LEDs.

6. Diagrams:





Formula:

$$h = \frac{eV_0\lambda}{c}$$

where, h - Plank’s constant

e - Charge (1.6×10^{-19} C)

V_0 - Threshold Voltage

λ - Wavelength of radiation

c- velocity of radiation (3×10^{8} m/s)

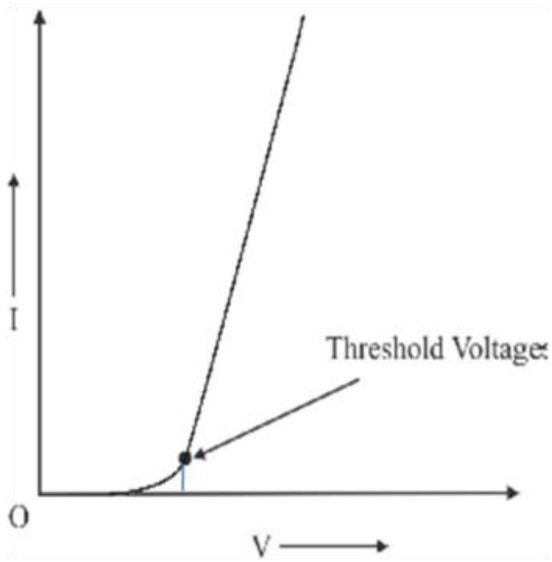
7. Observation Table:

1. For Red LED (λ = 700 nm) **2. For Green LED (λ= 560 nm)**
3. For Yellow LED (λ= 580 nm)

Sr. No.	Voltage **(V)**	Current **(mA)**	Sr. No.	Voltage **(V)**	Current **(mA)**	Sr. No.	Voltage **(V)**	Current **(mA)**
1.			1.			1.		
2.			2.			2.		
3.			3.			3.		
4.			4.			4.		
5.			5.			5.		
6.			6.			6.		
7.			7.			7.		
8.			8.			8.		
9.			9.			9.		
10.			10.			10.		
11.			11.			11.		
12.			12.			12.		

Graph:

Plot graph of Voltage **V** (X axis) vs. current **I** (Y axis) for different LEDs.



Find out value of Threshold voltage for each LED from the graph.

8. Calculations:

1. $h = \frac{eV_0\lambda}{c}$

2. Mean h =

9. Conclusion:

1. Planks constant h = ... Js (Experimental)
2. Planks constant h = ..6.63 x 10^-34...... Js (Theoretical)

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Viva Questions:

1) What do you mean by quanta and Plank's constant?
2) Why Si or Ge semiconductors are not used in LEDs?
3) Why LED gives monochromatic light and how do we get different colours in LED?

Experiment 6

1. **Aim:** To determine the energy gap of a germanium semiconductor diode.

2. **What will you learn by performing this experiment?**
   The temperature dependence of reverse saturation current due to minority charge carriers of semiconductor will be learnt. Photodiodes, diode temperature sensors etc. works on this principle.

3. **Apparatus:** Energy gap trainer kit, micro ammeter, digital multimeter, water heater, connectors.

4. **Theory:**
   One of the simplest methods of determining the energy gap E_g of a semiconductor material involves the study of variation in reverse saturation current of a p n-junction diode. The reverse saturation current is represented mathematically by the expression

$$\mathbf{I_s = AT^2 \exp(-E_g / kT)}$$

Where, I_s= reverse saturation current, A=material constant, E_g= energy gap,
K= Boltzmann's constant &T= Absolute temperature of the junction.
Thus,

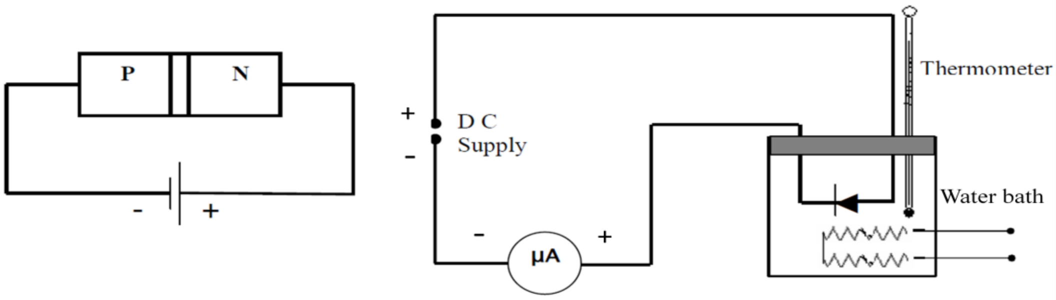
$$\mathbf{\ln (I_S/T^2) = -(e/kT) + \ln A}$$

And,

$$\mathbf{\log_{10} (I_S/T^2) = -(E_g/2.303\, k\, T) + constant}$$

Hence from the graph of log (I_S/T^2) Vs. (-1/T) the energy gap can be calculated as E =2.303 k × slope.

Diagram:



5.

Energy Band gap of Semiconductor

6. **Procedure:**
   1. Switch on the trainer kit.
   2. Insert the diode and the thermometer in close contact with each other inside the glass tube. Clamp the tube immersing it in the water in the water heater.
   3. Select the reverse bias voltage V_r of 2 volts at the input of the circuit.
   4. Connect the micro ammeter and the diode in the circuit.
   5. Note down the room temperature and the reverse saturation current.
   6. Switch on the water heater.
   7. Note down the magnitude of the reverse current I_S at various temperatures keeping the reverse voltage constant. Take readings at temperature intervals of 5 ^{0}C up to about 75 ^{0}C. Plot the graph of log (I/T) -vs- (1/T), determine its slope and calculate the energy gap E_g.

Observations:-

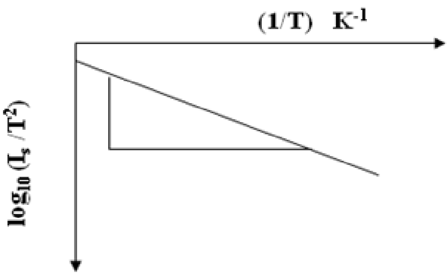
V_r= 2 volts

Obs. No.	Temp. T ^oC	Temp. T (K)	Rev. Sat. current I_s (μA)	$(I_s/T^2) \times 10^{-6}$ (A/K^2)	$\log_{10}(I_s/T^2)$
1	75				
2					
3					
4					
5					
6					

Calculations and Graph:

$$E_g = -2.303 \times K \times Slope$$

$$E_g = \frac{-2.303 \times 1.38 \times 10^{-23} \times Slope}{1.6 \times 10^{-19}} eV$$



7. **Results:** The band energy gap of Germanium is determined to be = Eg= …… eV.

8. **Conclusion and Discussion:**
   A small rise in temperature shows a large change in reverse saturation current showing it to be highly temperature sensitive.

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9. **QUIZ / Viva Questions:**
   1. Explain Diffusion and Drift Current?
   2. What is impact of reverse bias on p-n junction?
   3. What is importance of band gap in materials?

Experiment 7

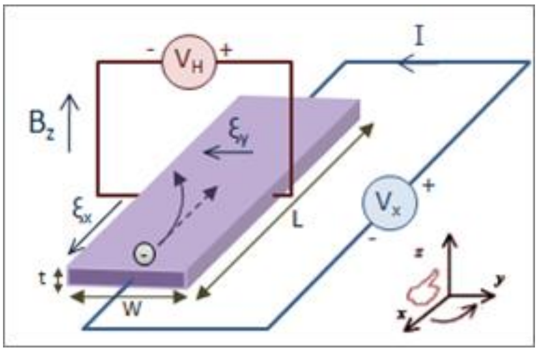
1. **Aim:** To calculate the Hall coefficient and the carrier concentration of the sample material.

2. **What will you learn by performing this experiment?**
Student will understand effect of magnetic field on charge carriers flowing through conductors and semiconductors**.** p type and n type semiconductor can be find out. Also carrier concentration can be calculated by using this experiment. Working principle of magnetic field sensor will also understand.

3. **Apparatus:** Electromagnet, Constant current supply, four probes, Digital gauss meter, Hall Effect apparatus (which consist of Constant Current source, digital milli-voltmeter and Hall probe).

4. **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 type 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 source, so that current I flow through the sample. If w is the width of the sample and t is the thickness. Therefore current density is given by

$$J_x = I/wt$$



Hall Effect

If the magnetic field is applied along positive z-axis, the Lorentz force given by

$$f_m = q(v \times B)$$

deflects the charge carriers (i.e. electrons) towards the negative y-direction causing an accumulation of charge carriers the left edge of the sample. This sets up a transverse electric field E_y in the sample developing a potential difference along the y-axis. This is known as Hall voltage V_H and this effect is called Hall Effect.

In steady state condition, the magnetic force is balanced by the electric force.

Mathematically we can express it as

$$eE_y = evB_z$$

Where e is the electric charge, Ey is the Hall electric field developed, B_z is the applied magnetic field and v is the drift velocity of charge carriers. And the drift current I_x can be expressed as,

$$I_x = nevA$$

Where n is the number density of electrons in the conductor of length l, width w and thickness t.

Using above equations the Hall voltage V_H can be written as,

$$V_H = wE_y = vwB_z = \frac{I_x B_z}{net}$$

$$V_H = R_H \frac{I_x B_z}{t}$$

Where, R_H is Hall Coefficient,

$$R_H = 1/ne$$

Formula:

$$\boldsymbol{R_H = \frac{V_H\, t}{I_x B_z}} \quad \textbf{(}\boldsymbol{\Omega}\ \textbf{m}^3\textbf{/ Wb) or (m}^3\textbf{/C)}$$

$$\boldsymbol{n = \frac{1}{eR_H} \quad /m^3}$$

5. Procedure:

1. Adjust the required gap between the electromagnets.
2. Connect the Hall Probe in to the probe socket.
3. Adjust probe current to zero and magnetic current to zero and observe V_H=0 volt.
4. Keep the magnetic current constant. Vary the probe current from -20 mA to +20 mA in steps of 2 mA. Note down the corresponding Hall voltages.
5. Then calculate Hall coefficient and carrier concentration using the equations.
6. Plot graph of Magnetic Field V_H -vs-I and calculate Hall Coefficient.

6. Observations:

I_m= 250 mA, **B= 1100 × 10^{-4}** wb/m^2 **Thicknss t =** 0.1 mm

Sr. Number	Probe Current I (mA)	Hall Voltage V_H (mV)	Hall Coefficient R_H (ohm-m^3/wb) x 10^-5	Charge Density n (/m^3) X 10^24
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

7. Results: Hall Coefficient of given material is **R_H** =........... **(Ω m^3/ Wb) or (m^3/C)**

8. Conclusion and Discussion:

1. Specimen used in this experiment is..........**P**..... type

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9. QUIZ / Viva Questions:

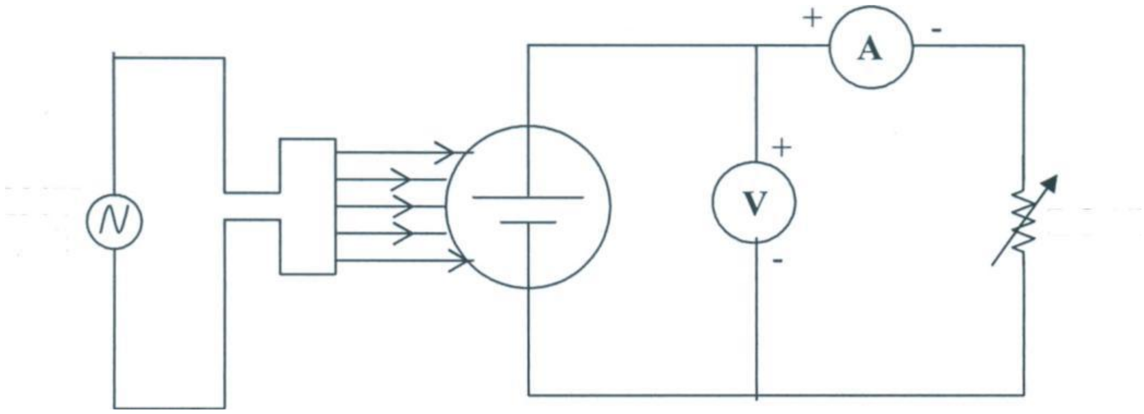
a) What is Hall Effect?
b) What is Fleming's Left Hand Rule?
c) Define Hall co-efficient.
d) Why is Hall potential developed?
e) How will you indentify n type or p type semiconductor?

Experiment 8

AIM: Study V-I characteristics of a solar cell.

APPARATUS: Solar cell, Illuminator, Voltmeter, Milliammeter and Potentiometer, etc.

CIRCUIT DIAGRAM:



THEORY:
The solar cell is a semi conductor device, which converts the solar energy into electrical energy. It is also called a photovoltaic cell. A solar panel consists of numbers of solar cells connected in series or parallel. The number of solar cell connected in a series generates the desired output voltage and connected in parallel generates the desired output current. The conversion of sunlight (Solar Energy) into electric energy takes place only when the light is falling on the cells of the solar panel. A solar cell operates in somewhat the same manner as other junction photo detectors. A built-in depletion region is generated in that without an applied reverse bias and photons of adequate energy create hole-electrons pairs. In the solar cell, as shown in Fig. 1a, the pair must diffuse a considerable distance to reach the narrow depletion region to be drawn out as useful current.

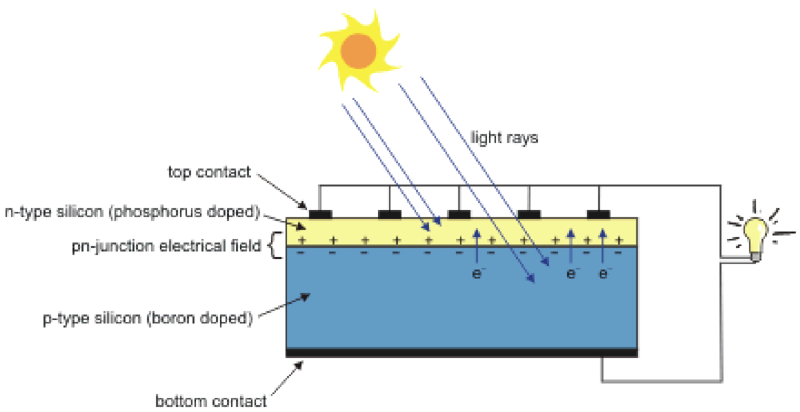


Fig. 1a Working principle of a solar Cell

Hence, there is higher probability of recombination.

The current generated by separated pairs increases the depletion region voltage

(Photovoltaic effect). When a load is connected across the cell, the potential causes the photocurrent to flow through the load. The e.m.f. generated by the photo-voltaic cell in the open circuit, i.e. when no current is drawn from it is denoted by VOC (V-open circuit). This is the maximum value of e.m.f.. When a high resistance is introduced in the external circuit a small current flows through it and the voltage decreases. The voltage goes on falling and the current goes on increasing as the resistance in the external circuit is reduced. When the resistance is reduced to zero the current rises to its maximum value known as saturation current and is denoted as ISC, the voltage becomes zero. A V-I characteristic of a photovoltaic cell is shown in Fig. 1b.

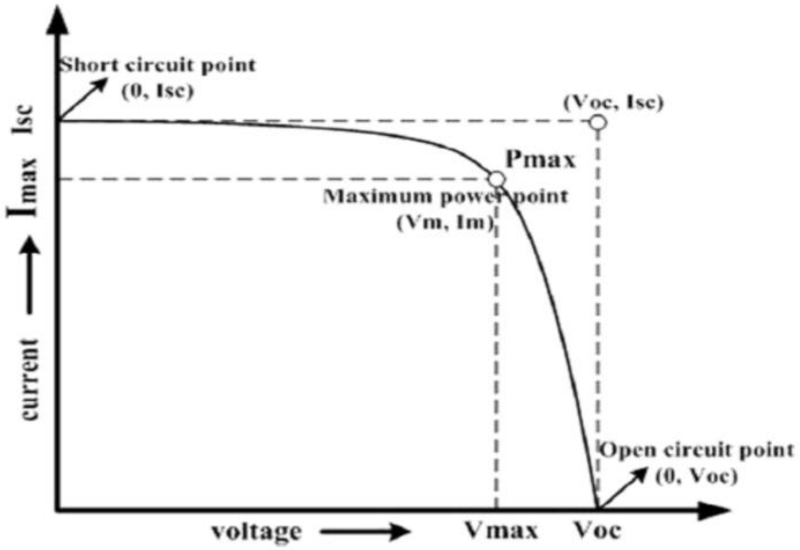


Fig1b I-V characteristic of a photovoltaic cell

The product of open circuit voltage VOC and short circuit current ISC is known a ideal power.

$$\text{Ideal Power} = VOC \times ISC$$

The maximum useful power is the area of the largest rectangle that can be formed under the V-I curve. If Vm and Im are the values of voltage and current under this condition, then

$$\text{Maximum useful power} = Vm \times Im$$

The ratio of the maximum useful power to ideal power is called the fill factor

$$Fill\ Factor = \frac{I_m \times V_m}{I_{Sc} \times V_{Oc}}$$

$$Efficiency = \frac{Maximum\ Power\ per\ unit\ area}{Input\ Power\ per\ unit\ area} = \frac{(I_m \times V_m)/m^2}{P_{In}/m^2}$$

PROCEDURE:

When experiment is performed with 100 Watt lamp:

1. Place the solar cell and the light source (100 watt lamp) opposite to each other on a wooden plank.
2. Connect the circuit as shown by dotted lines (Fig. 2) through patch chords.

Select the voltmeter range to 2V, current meter range to 250μA and load resistance (RL) to 50Ω.

3. Switch ON the lamp to expose the light on Solar Cell.
4. Set the distance between solar cell and lamp in such a way that current meter shows 250 μA deflections. Note down the observation of voltage and current in Table 1.

Vary the load resistance through band switch and note down the current and voltage readingsevery time in Table 1.

5. Plot a graph between output voltage vs. output current by taking voltage along X-axis and current along Y-axis.

Determining Fill factor:

Draw a rectangle having maximum area under the V-I curve and note the values of Vm and Im. Note the voltmeter reading for open circuit, VOC and milli ammeter reading with zero resistance ISC. Using these values, calculate the fill factor for the cell.

Observations:

1. Voltmeter reading for open cicuit, VOC = …. Volts
2. Milli ammeter reading with zero resistance, ISC = . . . mA.

Observation Table:

Sr. No.	Voltage	Current	Load
1			
2			
3			
4			
5			
6			
7			
8			

Calculation:

From Graph calculate Ideal Power, Maximum Power, Fill Factor and Efficiency of Solar Cell

Result:

1. **Ideal Power =**
2. **Maximum Power =**
3. **Fill Factor =**
4. **Efficiency =**

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VIVA VOICE QUESTIONS:

1. What is the difference between solar cell and a photodiode?
2. What are the types of semiconductor materials used for solar cell?