Faculty of Engineering & Technology, SRM University,
Kattankulathur – 603203

Program: B. Tech. [All Branches]

1. 15PY101L – Physics Instructional Manual

2. 15PY102L- Materials Science Instructional Manual

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SEMESTER-I

		L	T	P	C
	PHYSICS LABORATORY	**0**	**0**	**2**	**1**
15PY101L	**Total Contact Hours – 30**				
	Prerequisite				
	Nil				

PURPOSE	
The purpose of this course is to develop scientific temper in experimental techniques and to reinforce the physics concepts among the engineering students	
INSTRUCTIONAL OBJECTIVES	
1.	To gain knowledge in the scientific methods and learn the process of measuring different Physical variables
2.	Develop the skills in arranging and handling different measuring instruments
3.	Get familiarized with experimental errors in various physical measurements and to plan / suggest on how the contributions could be made of the same order, so as to minimize the errors.

LIST OF EXPERIMENTS

1. Determination of Young's modulus of a given material – Uniform / Non-uniform bending methods.
2. Determination of Rigidity modulus of a given material – Torsion pendulum
3. Determination of dispersive power of a prism – Spectrometer
4. Determination of laser parameters – divergence and wavelength for a given laser source –laser grating/ Particle size determination using laser
5. Study of attenuation and propagation characteristics of optical fiber cable
6. Calibration of voltmeter / ammeter using potentiometer
7. Construction and study of IC regulation properties of a given power supply
8. Study of V-I and V-R characteristics of a solar cell
9. Mini Project – Concept based Demonstration

References

1. G.L.Souires, "Practical Physics:, 4th Edition, Cambridge University, UK, 2001.
2. R.K.Shukla and Anchal Srivastava, "Practical Physics", 1st Edition, New Age International (P) Ltd, New Delhi, 2006.
3. D. Chattopadhyay, P. C. Rakshit and B. Saha, "*An Advanced Course in Practical Physics*", 2nd ed., Books & Allied Ltd., Calcutta, 1990

1 (a) DETERMINATION OF YOUNG'S MODULUS OF THE MATERIAL – UNIFORM BENDING

Aim

To calculate the Young's modulus of a given material using the method of uniform bending of beam

Apparatus Required

A uniform rectangular beam (wooden scale), two knife-edges, a pointer pin, slotted weights of the order of 50 gm , a spirit level, travelling microscope, a vernier caliper and screw gauge.

Principle

When an uniform load is acting on the beam, the envelope of the bent beam forms an arc of a circle and the bending is called uniform bending. The bending moment is, $W.x = \frac{YI_g}{R}$ where W = weight suspended in the beam, x = distance between the point at which the load is applied and the support, I_g = geometrical moment of inertia of the beam and R = radius of the circle made by the beam under load.

Formula

The Young's modulus (Y) of a given material of beam is,

$$Y = \frac{3Mgx}{2bd^3} \cdot \frac{l^2}{y} \quad \text{N m}^{-2}$$

where M = Mass suspended (kg)

g = Acceleration due to gravity = 9.8 m s $^{-2}$

x = Distance between the slotted weight and knife edge (m)

l = Distance between the two knife edge (m)

b = Breadth of the rectangular beam (m)

d = Thickness of the rectangular beam (m)

y = Elevation of the mid-point of the beam due to load.

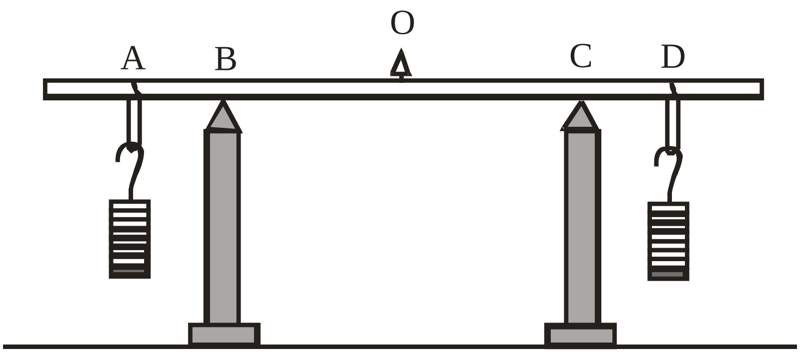


Fig 1.1 Young's Modulus – Uniform Bending

Table 1.1a: Determination of breadth (b) of the rectangular beam

LC = …….mm

S. No.	**MSR (mm)**	**VSC (div)**	**TR=MSR+VSC×LC (mm)**
		Mean	

Table 1.2a: Determination of thickness (d) of the rectangular beam

Z.E.C. = ………. mm L.C. = …………….. mm

Sl. No.	**PSR (mm)**	**HSC (div)**	**Observed Reading = PSR + (HSC × LC) (mm)**	**Corrected Reading = OR ±Z.E.C. (mm)**
			Mean	

Procedure

1. A uniform rectangular beam is placed on the two knife-edges in a symmetrical position. The distance between knife-edges is kept constant and is measured as *l*.
2. The weight hangers (dead load of the slotted weight) are suspended at points A and D on the beam at equal distance away from knife-edges. (i.e. the distance between AB and CD must be equal).
3. A pin is fixed at point O, exactly middle of the rectangular beam. The distance OB is equal to OC.
4. A microscope is arranged horizontally in front of scale and is focused at the tip of the pin. The microscope is adjusted such that the tip of the pin is coinciding with horizontal cross wire.
5. The equal dead weights (hanger) W_0 suspended on both side of the rectangular beam (at point A and D). The horizontal cross wire of the microscope is focused and coincides with the tip of the pin. The corresponding microscope reading (main scale reading and vernier scale reading) is noted from the vertical scale of microscope.
6. Then, additional load '*m*' (50 gm) is placed in the weight hangers on both sides simultaneously. Due to this load, there will be a small elevation on the rectangular beam and the height of the pin is increased.
7. The height of the microscope is adjusted in order to coincide the horizontal cross-wire with the tip of the pin. Once again, the main scale and vernier scale reading is noted from the vertical scale of microscope.
8. The experiment is continued by adding weights on both side of hanger for 2*m*, 3*m*, 4*m*, 5*m*…..etc. These reading correspondents to microscope reading on *loading*.
9. After adding all the weights, now the experiment to be carried out for *unloading*.

10. First, one weight (50 gm) is removed on both side, therefore there will be a depression in rectangular beam and the height of the pin is decreased. The microscope is adjusted again in order to coincide the horizontal cross-wire on the tip of the pin. The main scale and vernier scale readings are noted from the vertical scale of microscope.

11. Similarly, all the weights on both side of hanger are removed one by one and the corresponding microscope readings are noted. These readings are corresponding to microscope readings on unloading.

12. From these readings, the mean elevation of midpoint of the beam due to a load is determined.

Table 1.3a: Determination of mean elevation (y) of rectangular beam due to load

Distance between the knife edges = l = ……..m

LC for travelling microscope = ………m

Load on each weight hanger (kg)	**Microscope reading (cm)**			**Elevation for a load of *m* kg (cm)**	**Mean elevation for *m* kg (cm)**
	On Loading	**On unloading**	**Mean**		
W_0					
W_0+50					
W_0+100					
W_0+150					
W_0+200					

Observations

Distance between weight hanger and knife - edge = x = ... m
Distance between two knife-edges = l = ... m
Breadth of the rectangular beam = b = ... m
Thickness of the rectangular beam = d = ... m
Mean elevation = y = ... m

Calculations

The Young's modulus (Y) of the given beam can be calculated using the formula

$$Y = \frac{3Mgx}{2bd^3} \cdot \frac{l^2}{y} \ \text{N m}^{-2}$$

Result

The Young's modulus of a given material of beam = --------- N m^{-2}

1(b) DETERMINATION OF YOUNG'S MODULUS OF THE MATERIAL – NON UNIFORM BENDING

Aim

To calculate the Young's modulus of a given material using the method of non uniform bending of beam

Apparatus Required

A uniform rectangular beam (wooden scale), two knife-edges, a pointer pin, slotted weight of the order of 50 gm , a spirit level, travelling microscope, a vernier caliper and screw gauge.

Principle

A weight W is applied at the midpoint E of the beam. The reaction at each knife edge is equal to W/2 in the upward direction and 'y' is the depression at the midpoint E.The bent beam is considered to be equivalent to two single inverted cantilevers, fixed at E each of length $\left(\frac{l}{2}\right)$ and each loaded at K_1 and K_2 with a weight $\frac{W}{2}$

Formula

The Young's modulus (Y) of a given material of beam is,

$$Y = \frac{M\,gl^3}{4bd^3y}\ \mathrm{N\,m^{-2}}$$

where M = Mass suspended (kg)

g = Acceleration due to gravity = 9.8 m s $^{-2}$

l = Distance between the two knife edges (m)

b = Breadth of the rectangular beam (m)

d = Thickness of the rectangular beam (m)

y = Depression at the mid-point of the beam due to load.

Table 1.1b: Determination of breadth (b) of the rectangular beam

LC = …….mm

S. No.	MSR (mm)	VSC (div)	TR=MSR+VSC×LC (mm)

		Mean	

Table 1.2b: Determination of thickness (d) of the rectangular beam

Z.E.C. = ………. mm L.C. = …………….. mm

Sl. No.	PSR (mm)	HSC (div)	Observed Reading = PSR + (HSC × LC) (mm)	Corrected Reading = OR ±Z.E.C. (mm)
			Mean	

Procedure

1. A uniform rectangular beam is placed on the two knife-edges in a symmetrical position. The distance between knife-edges is kept constant and is measured as *l*.
2. A weight hanger is suspended and a pin is fixed vertically at mid-point. A microscope is focused on the tip of the pin.
3. A dead load Wo is placed on the weight hanger.The initial reading on the vertical scale of the microscope is taken.
4. A suitable mass M is added to the hanger. The beam is depressed. The cross wire is adjusted to coincide with the tip of the pin. The reading of the microscope is noted. The depression corresponding to the mass M is found.
5. The experiment is repeated by loading and unloading the mass (in steps of 50 gms). The corresponding readings are tabulated. The average value of depression, y is found from the observations.
6. From these readings, the mean elevation of midpoint of the beam due to a load is determined.
7. **Table 1.3b: Determination of mean depression (y) of rectangular beam due to load**

Distance between the knife edges = *l* = ……..m

LC for travelling microscope = ………m

Load in Kg	Microscope readings for depression			Mean depression, y for a load of M (cm)
	Load increasing cm	Load decreasing cm	Mean cm	
W				
W+50 gm				
W+100 gm				
W+150 gm				

W+200 gm				
W+250 gm				

Observations

Distance between two knife-edges = l = ... m

Breadth of the rectangular beam = b = ... m

Thickness of the rectangular beam = d = ... m

Mean depression = y = ... m

Calculations

The Young's modulus (Y) of the given beam can be calculated using the formula

$$Y = \frac{M\,gl^3}{4bd^3y} \text{ N m}^{-2}$$

Result

The Young's modulus of a given material of beam = --------- N m^{-2}

2. DETERMINATION OF RIGIDITY MODULUS OF THE MATERIAL - TORSIONAL PENDULUM

Aim

To determine the (i) moment of inertia of the disc and (ii) the rigidity modulus of the material of the wire by torsional oscillations.

Apparatus Required

Torsional pendulum, stop clock, screw gauge, scale, two equal masses.

Principle

1. Torsional pendulum is an angular form of the linear simple harmonic oscillator in which the element of springness or elasticity is associated with twisting a suspension wire.
2. The period of oscillation T of a torsional pendulum is given by

   $$T = 2\pi\sqrt{\frac{I}{C}}$$

   where I is the moment of inertia of the disc about the axis of rotation and C is the couple per unit twist of the wire.

Formulae

1. $I = 2m\left(d_2^2 - d_1^2\right)\left(\frac{T_0^2}{T_2^2 - T_1^2}\right)$ kg m^2

2. $N = \frac{8\pi I}{r^4}\left(\frac{l}{T_0^2}\right)$ N m^{-2}

where I = Moment of inertia of the disc (kg m^2)

N = Rigidity modulus of the material of the wire (N m^{-2})

m = Mass placed on the disc (kg)

d_1 = Closest distance between the suspension wire and centre of mass (m)

d_2 = Farthest distance between suspension wire and centre of mass (m)

T_0 = Time period without any mass placed on the disc (s)

T_1 = Time period when equal masses are placed at a distance d_1 (s)

T_2 = Time period when the equal masses are placed at a distance d_2 (s)

l = Length of the suspension wire (m)

r = Radius of the wire (m)

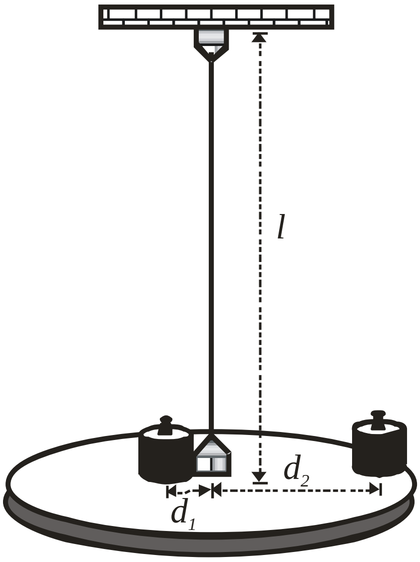


Fig. 2.1 Torsional Pendulum

Table 2.1: Measurement of the diameter of the wire using screw gauge:

Z.E.C. = ………. mm L.C. = …………….. mm

Sl.No.	PSR (mm)	HSC (div)	Observed Reading = PSR + (HSC x LC) (mm)	Corrected Reading = OR ±Z.E.C (mm)
			Mean	

Table 2.2: To determine $\left(\frac{l}{T_0^2}\right)$ **and** $\left[\frac{T_0^2}{\left(T_2^2 - T_1^2\right)}\right]$ **:**

S.No	Length of the suspension wire (m)	Time taken for 10 oscillations (s)			Time period (s)			$\left(\frac{l}{T_0^2}\right)$ ($m\ s^{-2}$)	$\left[\frac{T_0^2}{\left(T_2^2 - T_1^2\right)}\right]$
		without mass	with mass at d_1	with mass at d_2	T_0	T_1	T_2		
1									
2									
3									
							Mean		

Procedure

Step – I **To determine T_0**

1. One end of a long uniform wire whose rigidity modulus is to be determined is clamped by a vertical chuck. To the lower end of the wire, a circular metallic disc is attached. The length of the suspension wire is fixed to a particular value (say 50 cm).

2. This part of the experiment is performed without the equal cylindrical masses on the disc.

3. Twist the disc about its centre through a small angle. Now the disc makes torsional oscillations.

4. Omit the first few oscillations. The time taken for 10 complete oscillations are noted from the stop clock and the time period T_0 is determined.

Step – II **To determine T_1**

1. Two equal masses *m* are placed on either side, close to the suspension wire.

2. Measure the closest distance d_1 from the centre of mass and the centre of the suspension wire.

3. The disc with masses at distance d_1 is made to execute torsional oscillations.

4. Note the time taken for 10 oscillations and calculate the time period T_1.

Step – III **To determine T_2**

1. Place the equal masses such that the edges of masses coincide with the edge of the disc and centres are equidistant.

2. Measure the distance d_2 between the centre of the disc and the centre of mass.

3. Set the pendulum in to torsional oscillations and note the time taken for 10 oscillations. Calculate the time period T_2.

Step – IV Repeat the above procedure for different length of the wire (say 60 and 70 cm)

Step – V Determine the radius of the wire using screw gauge.

Observations:

Mass placed on the disc (m) = …….. $\times 10^{-3}$ kg

Distance (d_1) = ………$\times 10^{-2}$ m

Distance (d_2) = ………$\times 10^{-2}$ m

Mean radius of the wire (r) = ………$\times 10^{-3}$ m

$\left(\frac{l}{T_0^2}\right)$ value from table = ………. m s $^{-2}$

$\left(\frac{l}{T_0^2}\right)$ value from graph = ………. m s $^{-2}$

Mean $\left[\frac{T_0^2}{\left(T_2^2 - T_1^2\right)}\right]$ **= ………**

Calculations:

(i) Compute $\left(\dfrac{l}{T_0^2}\right)$ for each length.

(ii) Compute $\left[\dfrac{T_0^2}{\left(T_2^2 - T_1^2\right)}\right]$ for each length.

(iii) Find the mean value of $\left(\dfrac{l}{T_0^2}\right)$ and $\left[\dfrac{T_0^2}{\left(T_2^2 - T_1^2\right)}\right]$.

(iv) Mean value of $\left[\dfrac{T_0^2}{\left(T_2^2 - T_1^2\right)}\right]$ is substituted in $I = 2m\left(d_2^2 - d_1^2\right)\left(\dfrac{T_0^2}{T_2^2 - T_1^2}\right)$ to get the moment of inertia of the disc.

(v) $\left(\dfrac{l}{T_0^2}\right)$ is substituted in $N = \dfrac{8\pi I}{r^4}\left(\dfrac{l}{T_0^2}\right)$ to get rigidity modulus of the given wire.

Graph

Plot a graph between length of the suspension wire l along X – axis and square of the time period without masses on disc T_0^2 along Y – axis. The graph is a straight line.

Result

1. Moment of inertia of the disc = ……… km m^2
2. The rigidity modulus of the wire

(a) by calculation = ……… N m^{-2}

(b) by graph = ………. N m^{-2}

3. DETERMINATION OF DISPERSIVE POWER OF A PRISM USING SPECTROMETER

Aim

To determine the dispersive power of a given prism for any two prominent lines of the mercury spectrum.

Apparatus Required

A spectrometer, mercury vapour lamp, prism, spirit level, reading lens etc.

Formulae

1. Refractive index of the prism for any particular colour

$$\mu = \frac{\sin\left(\frac{A+D}{2}\right)}{\sin\left[\frac{A}{2}\right]}$$

where A = Angle of the prism in (deg)

D = Angle of minimum deviation for each colour in (deg)

2. The dispersive power of the prism is

$$\omega = \frac{\mu_1 - \mu_2}{\left(\frac{\mu_1 + \mu_2}{2}\right) - 1}$$

where μ_1 and μ_2 are the refractive indices of the given prism for any two colours.

Procedure

Part I : To determine the angle of the prism (A)

1. The initial adjustments of the spectrometer like, adjustment of the telescope for the distant object, adjustment of eye piece for distinct vision of cross –wires, levelling the prism table using spirit level, and adjustment of collimator for parallel rays are made as usual.
2. Now the slit of the collimator is illuminated by the mercury vapour lamp.
3. The given prism is mounted vertically at the centre of the prism table, with its refracting edge facing the collimator as shown in figure (6.4) (i.e.) the base of the prism must face the telescope. Now the parallel ray of light emerging from the collimator is incident on both the refracting surfaces of the prism.
4. The telescope is released and rotated to catch the image of the slit as reflected byone refracting face of the prism.

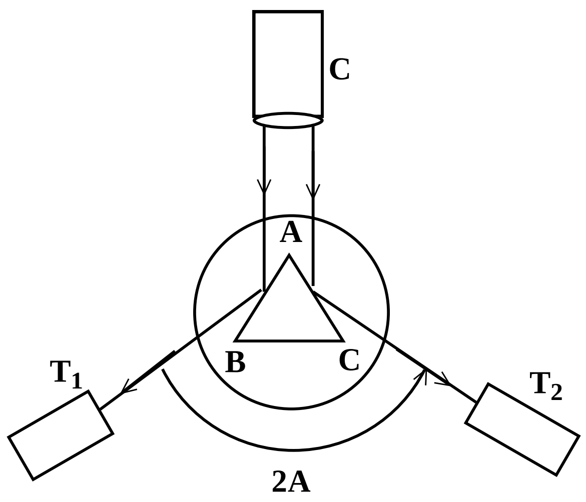


Fig.3.1 Spectrometer – Angle of Prism

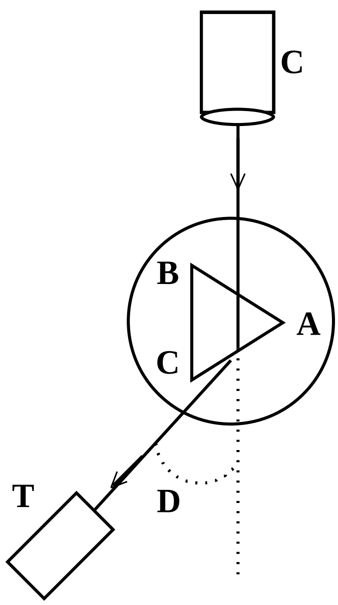


Fig.3.2 Angle of Minimum Deviation

Observations

$$LC = \frac{\text{Value of one MSD}}{\text{No. of div on VS}} = \frac{30'}{30} = 1'$$

Table 3.1: To determine the angle of prism (A)

LC = 1’ TR = MSR + (VSC ×LC)

Position of the reflected ray	**Vernier –A**			**Vernier-B**		
	MSR degree	**VSC div**	**T.R degree**	**MSR degree**	**VSC div**	**T.R degree**
Left side			(R_1)			(R_3)
Right Side			(R_2)			(R_4)
	$2A = (R_1 - R_2) =$ $\therefore A = \frac{R_1 - R_2}{2}$ A=			$2A = (R_3 - R_4) =$ $\therefore A = \frac{R_3 - R_4}{2}$ $\therefore$A=		

$\therefore$ Mean A =

5. The telescope is fixed with the help of main screw and the tangential screw is adjusted until the vertical cross-wire coincides with the fixed edge of the image of the slit. The main scale and vernier scale readings are taken for both the verniers.

6. Similarly the readings corresponding to the reflected image of the slit on the other face are also taken. The difference between the two sets of the readings gives twice the angle of the prism (2A). Hence the angle of the prism A is determined.

Part 2 : To determine the angle of the minimum deviation (D) and Dispersive power of the material of the prism

1. The prism table is turned such that the beam of light from the collimator is incident on one polished face of the prism and emerges out from the other refracting face. The refracted rays (constituting a line spectrum) are received in the telescope Fig.6.5.

2. Looking through the telescope the prism table is rotated such that the entire spectrum moves towards the direct ray, and at one particular position it retraces its path. This position is the minimum deviation position.

3. Minimum deviation of one particular line, say violet line is obtained. The readings of both the verniers are taken.
4. In this manner, the prism must be independently set for minimum deviation of red line of the spectrum and readings of the both the verniers are taken.
5. Next the prism is removed and the direct reading of the slit is taken.
6. The difference between the direct reading and the refracted ray reading corresponding to the minimum deviation of violet and red colours gives the angle of minimum deviation (D) of the two colours.
7. Thus, the refractive index for each colour is calculated, using the general formula.

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

and Dispersive power of the prism.

$$\omega = \frac{\mu_1 - \mu_2}{\left(\frac{\mu_1 + \mu_2}{2}\right) - 1}$$

Table 3.2: To determine the angle of the minimum deviation (D) and Dispersive power of the material of the prism:

Direct ray reading (R_1) : Vernier A : Vernier B:

<table>
<tr><th rowspan="3">Line</th><th colspan="6">Refracted ray readings when the prism is in minimum deviation position(R_2)</th><th colspan="2">Angle of minimum deviation (D) (= $R_1 \sim R_2$)</th><th rowspan="3">Mean D</th><th rowspan="3">Refractive index ‘μ’</th></tr>
<tr><th colspan="3">Vernier –A</th><th colspan="3">Vernier –B</th><th rowspan="2">Vernier –A degree</th><th rowspan="2">Vernier-B degree</th></tr>
<tr><th>MSR degree</th><th>VSC div</th><th>TR degree</th><th>MSR Degree</th><th>VSC div</th><th>T.R degree</th></tr>
<tr><td>Violet</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Red</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

LC=1’ TR = MSR + (VSC ×LC)

Result

The dispersive power of the material of the prism is -------------

4(a) DETERMINATION OF LASER PARAMETERS – DIVERGENCE AND WAVELENGTH FOR A GIVEN LASER SOURCE USING LASER GRATING

Aim

To determine the divergence and wavelength of the given laser source using standard grating.

Apparatus Required

Laser source, grating, a screen etc.,

Principle

When a composite beam of laser light is incident normally on a plane diffraction grating, the different components are diffracted in different directions. The m^{th} order maxima of the wavelength λ, will be formed in a direction θ if $d \sin \theta = m\lambda$, where d is the distance between two lines in the grating.

Formula

1. The angle of divergence is given by

$$\Phi = \frac{(a_2 - a_1)}{2(d_2 - d_1)}$$

where a_1 = Diameter of the laser spot at distance d_1 from the laser source

a_2 = Diameter of the laser spot at distance d_2 from the laser source

2. The wavelength of the laser light is given by

$$\lambda = \frac{\sin\theta_m}{Nm} \quad \text{m}$$

where	m	=	Order of diffraction
	θ_n	=	Angle of diffraction corresponding to the order m
	N	=	number of lines per metre length of the grating
	θ	=	$\tan^{-1}$ (x/D)
	x	=	Distance from the central spot to the diffracted spot (m)
	D	=	Distance between grating and screen(m)

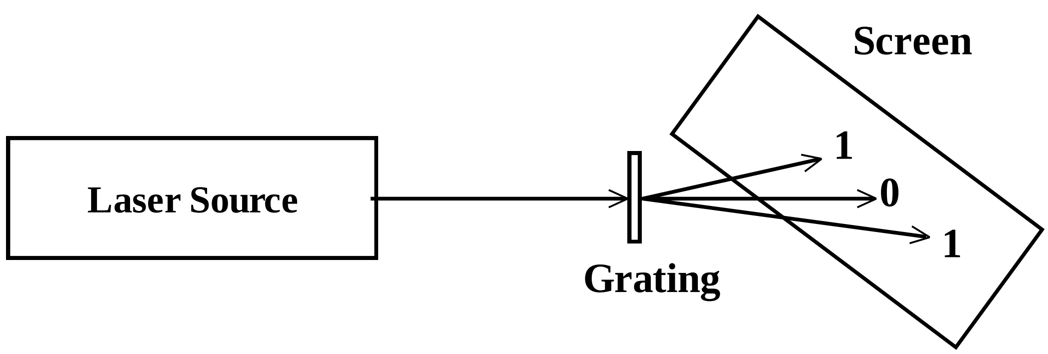


Fig.4.1a Experimental Setup for Laser Grating

Table 4.1a: Determination of wave length of Laser Light:

Distance between grating and screen (D) = ----------- m

Number of lines per metre length of the grating = N = --------------

S.No	Order of Diffraction (m)	Distance of Different orders from the Central Spot (x) m		Mean (x) m	Angle of diffraction $\theta = \tan^{-1}[x / D]$	$\lambda = \frac{\sin\theta_m}{Nm}$ Å
		Left	Right			

Procedure

Part 1: Determination of angle of divergence

1. Laser source is kept horizontally.
2. A screen is placed at a distance d_1 from the source and the diameter of the spot (a_1) is measured.
3. The screen is moved to a distance d_2 from the source and at this distance, the diameter of the spot (a_2) is measured.

Part 2: Determination of wavelength

1. A plane transmission grating is placed normal to the laser beam.
2. This is done by adjusting the grating in such a way that the reflected laser beam coincides with beam coming out of the laser source.
3. The laser is switched on. The source is exposed to grating and it is diffracted by it.
4. The other sides of the grating on the screen, the diffracted images (spots) are seen.
5. The distances of different orders from the central spot are measured.
6. The distance from the grating to the screen (D) is measured.
7. θ is calculated by the formula $\theta = \tan^{-1}(x/d)$.
8. Substituting the value of θ, N and m in the above formula, the wavelength of the given monochromatic beam can be calculated.

Result

1. The angle of divergence is = -----------.
2. The wavelength of the given monochromatic source is = ----------- Å

4(b). PARTICLE SIZE DETERMINATION USING LASER

Aim

To determine the size of micro particles using laser.

Apparatus Required

Fine micro particles having nearly same size (say lycopodium powder), a glass plate (say microscopic slide), diode laser, and a screen.

Principle

When laser is passed through a glass plate on which fine particles of nearly uniform size are spread, due to diffraction circular rings are observed. From the measurement of radii of the observed rings, we can calculate the size of the particles. Since for diffraction to occur size of the obstacle must be comparable with wavelength, only for extremely fine particles of micron or still lesser dimension, diffraction pattern can be obtained.

Diffraction is very often referred to as the bending of the waves around an obstacle. When a circular obstacle is illuminated by a coherent collimated beam such as laser light, due to diffraction circular rings are obtained as shown in the figure 3.1 . If “r” is the radius of the first dark ring and “D” is the distance between the obstacle and screen on which the diffraction pattern is obtained, then.

$$\tan\theta = \frac{r}{D}$$

Since θ is very small in this experiment

$$\tan\theta = \theta = \frac{r}{D}$$

According to the theory, the diameter 1a’ of the circular obstacle is given by

$$2a = \frac{1.22 n\lambda D}{r_n}$$

where

r_n	=	radius of the n^{th} order dark ring (m)
D	=	distance between the obstacle and the screen (m)
λ	=	wavelength of the laser light (Å)

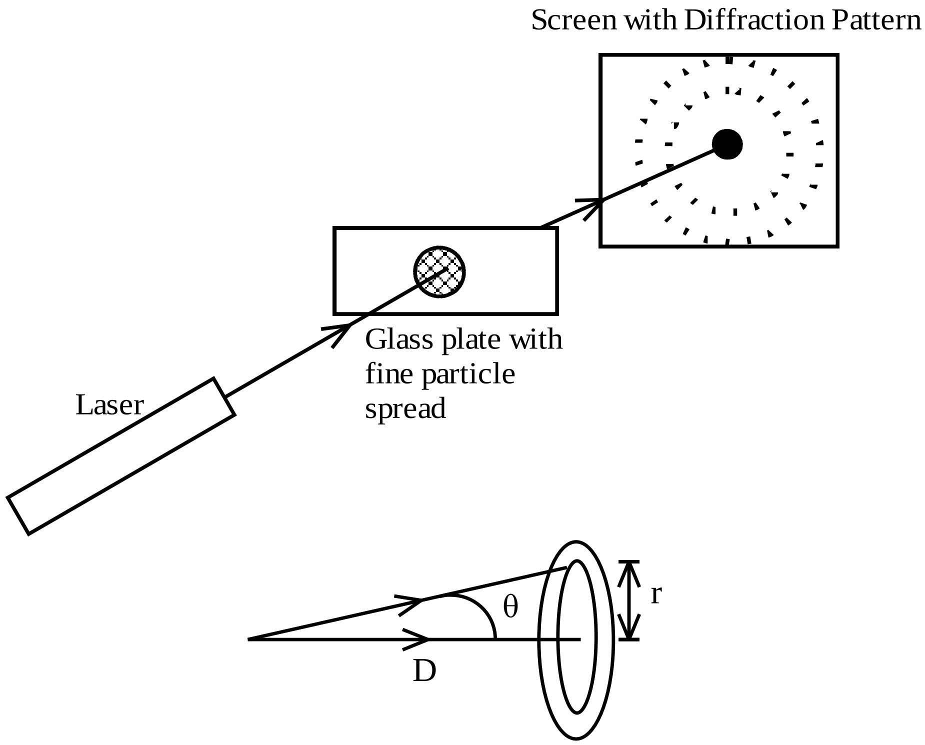


Fig. 4.1b Particle size determination using Laser

Table 4.1b. Determination of particle size

Sl.No.	**Distance (D)**	**Diffraction order (n)**	**Radius of dark ring (r_n)**	**Particle size (2a)**
Unit	m		m	m
1		1 2		
2		1 2		
3		1 2		
			Mean	

Procedure

1. Fine powder of particles is sprayed/spread on the glass plate.
2. Laser is held horizontally and the glass plate is inserted in its path.

3. Position of the glass plate is adjusted to get maximum contrast rings on the screen which is at a distance more than 0.5 m.

4. A white paper is placed on the screen and the positions of the dark rings are marked. The radii of different order dark rings (r_n) are measured using a scale.

5. The distance between the screen and the glass plate (D) is also measured. Using the given formula, the average diameter of the particles is calculated. $2a = \frac{1.22 n\lambda D}{r_n}$

6. The experiment is repeated for different D values.

Result

The average size of the particles measured using laser = ...μm

5. STUDY OF ATTENUATION AND PROPAGATION CHARACTERISTICS OF OPTICAL FIBER CABLE

I . ATTENUATION IN FIBERS

Aim

(i) To determine the attenuation for the given optical fiber.

(ii) To measure the numerical aperture and hence the acceptance angle of the given fiber cables.

Apparatus Required

Fiber optic light source, optic power meter and fiber cables (1m and 5m), Numerical aperture measurement JIG, optical fiber cable with source, screen.

Principle

The propagation of light down dielectric waveguides bears some similarity to the propagation of microwaves down metal waveguides. If a beam of power P_i is launched into one end of an optical fiber and if P_f is the power remaining after a length L km has been traversed , then the attenuation is given by,

$$\text{Attenuation} = \frac{10\log\left(P_i / P_f\right)}{L} \text{ dB / km}$$

Formula

$$\text{Attenuation (dB / km)} = \frac{10\log\left(P_i / P_f\right)}{L}$$

Procedure

1. One end of the one metre fiber cable is connected to source and other end to the optical power metre.
2. Digital power meter is set to 200mV range (- 200 dB) and the power meter is switched on
3. The ac main of the optic source is switched on and the fiber patch cord knob in the source is set at one level (A).
4. The digital power meter reading is noted (P_i)
5. The procedure is repeated for 5m cable (P_f).
6. The experiment is repeated for different source levels.

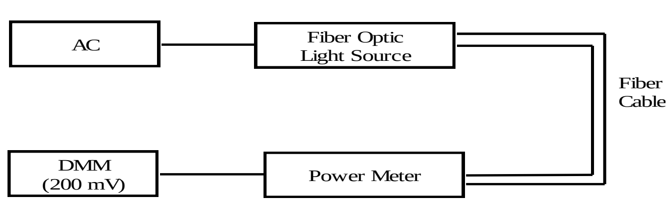


Fig.5.1 Setup for loss measurement

Table 5.1: Determination of Attenuation for optical fiber cables

L = 4 m = 4×10^{-3} km

Source Level	**Power output for 1m cable (P_i)**	**Power output for 5m cable (P_f)**	**Attenuation =** $\dfrac{10\log\left(P_i / P_f\right)}{L}$ **dB / km**

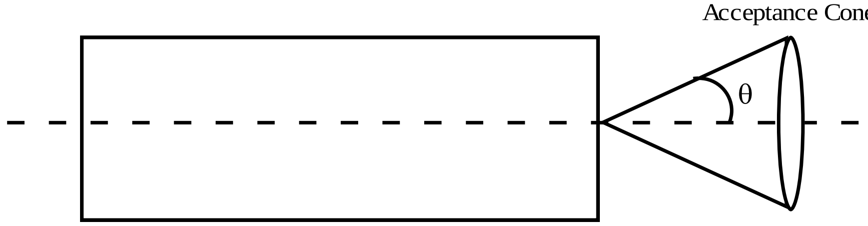


Fig. 5.2. Numerical Aperture

Table 5.2: Measurement of Numerical Aperture

Circle	**Distance between source and screen (L) (mm)**	**Diameter of the spot W (mm)**	**NA =** $\dfrac{W}{\sqrt{4L^2 + W^2}}$	**θ**

Result

1.Attenuation at source level A = ----------- (dB/km)

2. Attenuation at source level B = ----------- (dB/km)

3. Attenuation at source level C = ----------- (dB/km)

II. Numerical Aperture

Principle

Numerical aperture refers to the maximum angle at which the light incident on the fiber end is totally internally reflected and transmitted properly along the fiber. The cone formed by the rotation of this angle along the axis of the fiber is the cone of acceptance of the fiber.

Formula

$$\text{Numerical aperture (NA)} = \frac{W}{\sqrt{4L^2 + W^2}} = \sin\theta_{max}$$

Acceptance angle = 2 θ_{max} (deg)

where L = distance of the screen from the fiber end in metre

W =diameter of the spot in metre.

Procedure

1. One end of the 1 metre fiber cable is connected to the source and the other end to the NA jig.
2. The AC mains are plugged. Light must appear at the end of the fiber on the NA jig. The set knob in source is turned clockwise to set to a maximum output.
3. The white screen with the four concentric circles (10, 15, 20 and 25mm diameters) is held vertically at a suitable distance to make the red spot from the emitting fiber coincide with the 10mm circle.
4. The distance of the screen from the fiber end L is recorded and the diameter of the spot W is noted. The diameter of the circle can be accurately measured with the scale. The procedure is repeated for 15mm, 20mm and 25mm diameter circles.
5. The readings are tabulated and the mean numerical aperture and acceptance angle are determined.

Result

i) The numerical aperture of fiber is measured as ....

ii) The acceptance angle is calculated as .... (deg).

6(a) CALIBRATION OF VOLTMETER USING POTENTIOMETER

Aim

To calibrate the given voltmeter by potentiometer. (i.e. To check the graduations of voltmeter and to determine the corrections, if any).

Apparatus Required

Potentiometer, rheostat, battery (2V) (or) accumulators, keys, Daniel cell, high resistance, sensitive table galvanometer, given voltmeter, connecting wires etc.

Formulae

Calibrated voltage $V' = \frac{1.08}{l_0} l \ (volt)$

where l_0 = Balancing length corresponding to e.m.f. of Daniel cell (m)

l =Balancing length for different voltmeter reading (m)

Procedure

Part 1 : To standardize the potentiometer (or) To find the potential fall across one metre length of the potentiometer

1. The circuit connections are made as shown in fig. (6.10) and is described below.
2. A primary circuit is made by connecting the positive terminal of a battery to the end A of the potentiometer and its negative terminal to the end B through a key (K_1).
3. A secondary circuit is made by connecting the positive terminal of the Daniel cell to A and its negative to the jockey through a high resistance (HR) and a sensitive galvanometer.
4. The rheostat is adjusted to send a suitable current through the circuit.
5. Since the accumulator has a constant e.m.f. the potential drop across the potentiometer wire remains steady.
6. Next the jockey is moved along and pressed along the 10-metre potentiometer wire, till the position for the null deflection is found in the galvanometer.

Circuit Diagrams

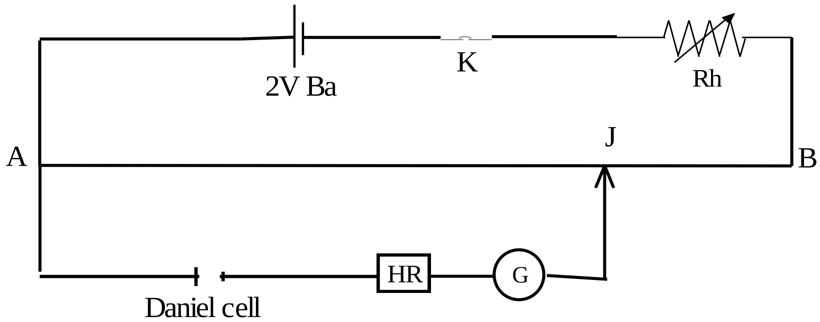


Fig.6.1aStandardisation of Potentiometer

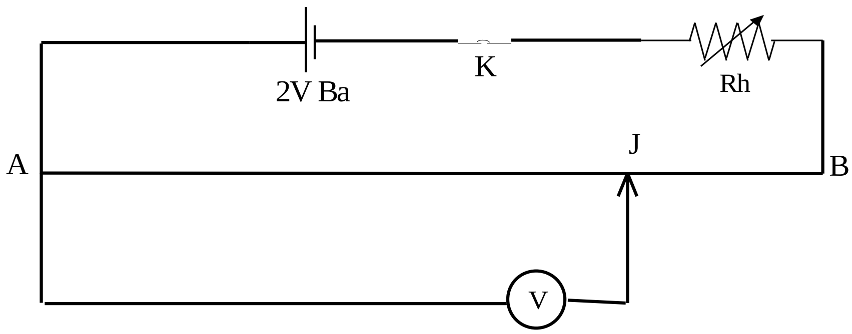


Fig.6.2a Calibration of Voltmeter

Observations

Table 6.1: To calibrate the given voltmeter

Length of the wire balancing the e.m.f. of the Daniel cell (l_0) = …… $\times 10^{-2}$ m

S. No.	Voltmeter reading (V) volt	Balancing Length (l) m	Calculated voltmeter reading $V' = \frac{1.08}{l_0} \times l \ (volt)$	Correction (V′– V) Volt

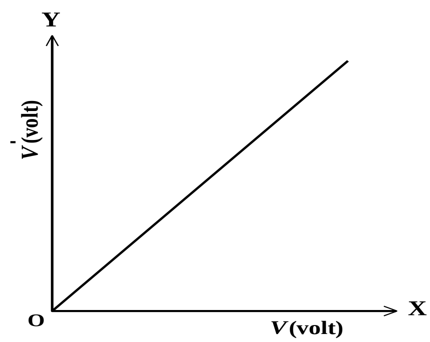


Fig. 6.3a Model Graph (*V vs V'*)

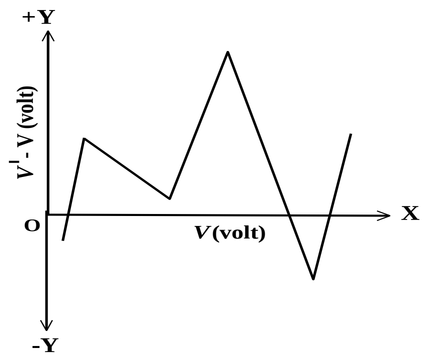


Fig. 6.4a Model Graph V vs (*V' – V*)

7. Let the balancing length be l_0 meter (AJ). Then, the potential drop per unit length of the potentiometer $\frac{1.08}{l_0}$ is calculated. The rheostat should not be disturbed hereafter.

Part 2: To calibrate the given voltmeter

1. The Daniel cell, high resistance (HR) and the galvanometer are replaced by the given low range voltmeter which is to be calibrated. The positive terminal of the voltmeter is connected to A and its negative terminal to the jockey[figure (6.11)]

2. By trial, the jockey is moved along the wire, and by pressing at different points, the length *l* m of the potentiometer wire which gives a reading of 0.1 volt in the voltmeter is determined.

3. The experiment is repeated by finding similar balancing lengths for voltmeter readings of 0.2, 0.3, ……1 V. Knowing the p.d meter length of the wire (l_0), the actual p.d. V' corresponding to these reading are calculated and the corrections in these readings are determined.

Graph

1. A graph between the voltmeter reading (V) along the X-axis and the correction (V'-V) along the Y-axis is drawn.

2. A graph of observed voltmeter reading (V) along the X-axis and calculated voltages (V') along the Y-axis may also be drawn.

Result

The given voltmeter is calibrated.

6(b) CALIBRATION OF AMMETER USING POTENTIOMETER

Aim

To calibrate the given ammeter by potentiometer. (i.e. To check the graduations of ammeter and to determine the corrections, if any).

Apparatus Required

Potentiometer, rheostat, batteries (2V and 6V) (or) accumulators, keys, Daniel cell, high resistance, sensitive table galvanometer, the given ammeter, a standard resistance (1 Ω) (or) a dial type resistance box (1–10 ohm) connecting wires etc.

Formulae

Calibrated current passing through standard resistance

$$i' = \frac{1.08}{R\ell_0}\ell\ (amp)$$

where R= Standard resistance (1 Ω)

l = Balancing length for different ammeter readings (m)

l_0 = Balancing length corresponding to e.m.f. of Daniel cell (m)

Procedure

Part 1 : To standardize the potentiometer (or) To find the potential fall across one metre length of the potentiometer

1. The circuit connections are made as shown in fig. (6.14) and is described below.
2. A primary circuit is made by connecting the positive terminal of a battery to the end A of the potentiometer and its negative terminal to the end B through a key (K_1).
3. A secondary circuit is made by connecting the positive terminal of the Daniel cell to A and its negative to the jockey through a high resistance (HR) and a sensitive galvanometer.
4. The rheostat is adjusted to send a suitable current through the circuit.
5. Since the accumulator has a constant e.m.f. the potential drop across the potentiometer wire remains steady.
6. Next the jockey is moved along and pressed along the 10-metre potentiometer wire, till the position for the null deflection is found in the galvanometer.

Circuit Diagrams

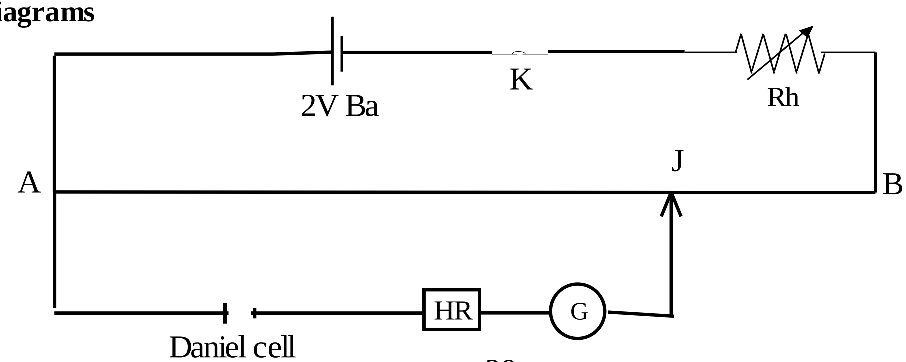


Fig.6.1bStandardisation of Potentiometer

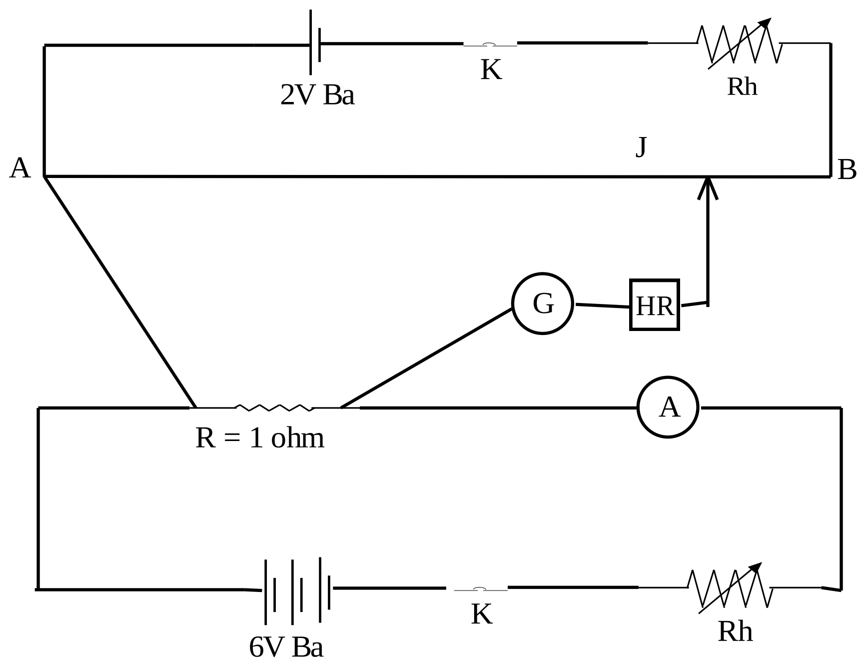


Fig.6.2b Calibration of Ammeter

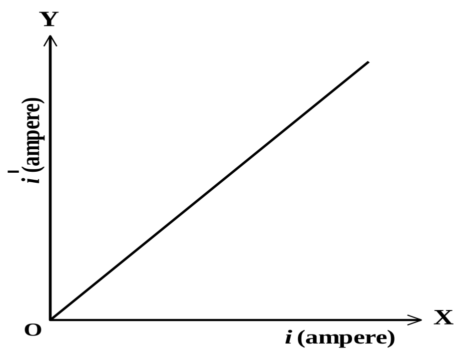
Observations

Table 6.1b: To calibrate the given ammeter

Balancing length l_0 = ……… $\times 10^{-2}$ m

(Length of the wire balancing the emf of the Daniel cell)

S.No.	**Ammeter reading** **i (A)**	**Length balancing the p.d across l ohm coil** ***l* m**	**Calculated ammeter reading** $i' = \frac{1.08}{l_0} \times l$ **(A)**	**Correction** **(I′–i) (A)**



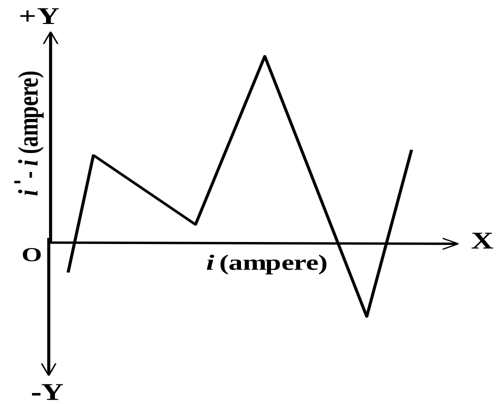


Fig.6.3b Model Graph (*i vs i'*)

Fig. 6.4b. Model Graph *i* vs (*i' – i*)

7. Let the balancing length be l_0 meter (AJ). Then, the potential drop per unit length of the potentiometer $\frac{1.08}{l_0}$ is calculated. The rheostat should not be disturbed hereafter.

Part 2 : To calibrate the given ammeter

1. In order to calibrate the given ammeter, the primary circuit of the potentiometer is left undisturbed.
2. In the secondary circuit the voltmeter is replaced by a standard one-ohm resistance (or a dial resistance box).
3. One end of one ohm resistance is connected to A and the other end is connected to jockey through a high resistance (HR) and galvanometer [figure (6.15)].
4. In addition an ammeter, plug key (K_2), a rheostat and a 6V battery are connected in series to ends of one ohm standard resistance.
5. The rheostat of the ammeter is adjusted to read 0.1 A and the jockey is moved and pressed to get null deflection in the galvanometer. The second balancing length l m is determined, and i' is calculated using the given formula.
6. The experiment is repeated by adjusting the rheostat in the secondary circuit, so that the ammeter readings are successively 0.2, 0.3, …..1 ampere.
7. The current flowing through the circuit is calculated in each case and the corrections to the readings of the ammeter (i' – i) are tabulated.

Graph

1. A graph between ammeter reading (*i*) along the X-axis and the correction (*i' – i*) along the y – axis is drawn.
2. A graph between ammeter reading (*i*) and calculated ammeter reading *i'* is also drawn.

Result

The given ammeter is calibrated.

7.CONSTRUCTION AND STUDY OF REGULATION PROPERTIES OF A GIVEN POWER SUPPLY USING IC

Aim

To study the regulation characteristics of an IC regulated power supply.

Apparatus Required

Unregulated power supply (Bridge rectifier), IC 7805 chip, capacitors, voltmeter, etc.

Procedure

An IC regulator chip incorporates a circuit containing filter and regulating Zener diodes. It is a readymade circuitry which minimises the connections. IC regulator chips come out as 78... series where the numbers after 78 indicate the output voltage available from it. For example, IC 7805 provides an output of 5 V, IC 7808 gives 8 V and so on.

The circuit connections are made as shown in Fig. 6.18.

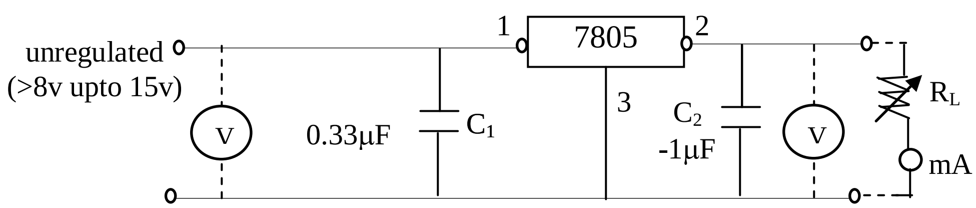


Fig.7.1 IC regulated for supply

An unregulated power supply is connected to the IC regulator chip as shown. The capacitor C_1 helps in bypassing any a.c. component present in the input voltage while the capacitor C_2 helps in keeping the output resistance of the circuit low at high frequencies.

The experiment may be carried out in two steps:

(i) Study of regulation properties when input voltage is varied:

The input voltage is varied over the allowed range for the given IC chip and the output voltage is measured. A graph may be drawn with input voltage along X-axis and output voltage along Y-axis.

(ii) Study of regulation properties with load current: Like in the Zener regulated power supply experiment, the output voltage is measured for various values of load current. The independence of output voltage over an allowed range of load current may be seen.

Readings are tabulated as follows:

(i) **Table 7.1: INPUT / OUTPUT characteristics**

Trial	Input voltage Volts	Output voltages volts
1		
2		
3		
4		
5		

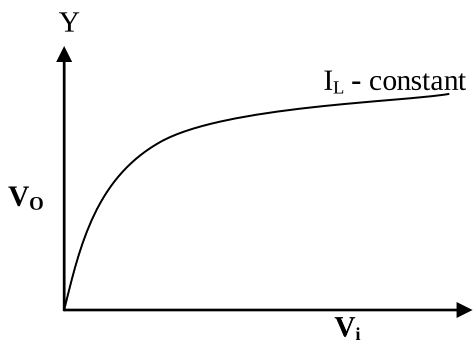


Fig.7.2 Model graph (Line regulation)

(ii) Table 7.2: OUTPUT vs. LOAD CURRENT characteristics

Trial No.	Load current mA.	Output voltage volts.

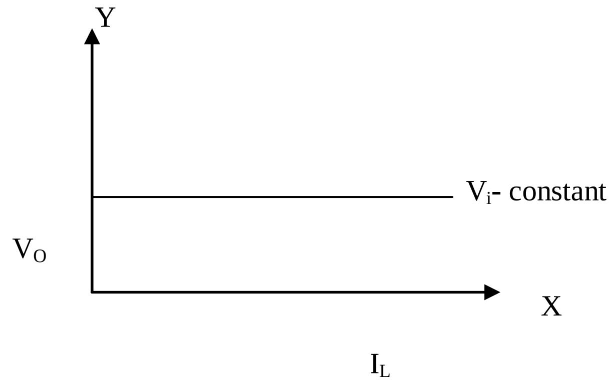


Fig.7.3 Model graph (Load regulation)

Result:

The power supply using IC was constructed and the regulation properties were studied. The characteristics graphs are drawn.

8.STUDY OF V-I AND V-R CHARACTERISTICS OF A SOLAR CELL

Aim

To study the V-I and V-R characteristics of a solar cell.

Apparatus Required

Solar cell, voltmeter,milliammeter, a dial type resistance box, Keys, illuminating lamps, connecting wires etc.

Procedure

A solar cell (photovoltaic cell) essentially consists of a p-n junction diode, in which electrons and holes are generated by the incident photons. When an external circuit is connected through the p-n junction device, a current passes through the circuit. Therefore, the device generates power when the electromagnetic radiation is incident on it.

The schematic representation of a solar cell and the circuit connections are as shown in Fig. 7.1.

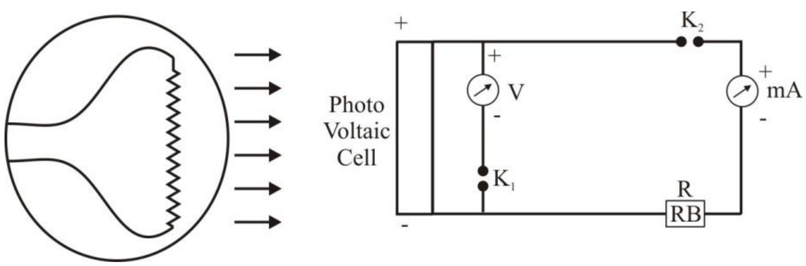


Fig.8.1 Schematic representation and circuit of Solar Cell

The voltmeter is connected in parallel with the given solar cell through a plug key. A milliammeter and a variable resistor are connected in series to the solar cell through a key as shown in the Fig.6.21.

The solar cell can be irradiated by sun's radiation. Instead, it can also be irradiated by a filament bulb (60 W or 100 W).

The resistance value is adjusted by a ressitance box and the variation of V-I and V-R are plotted.

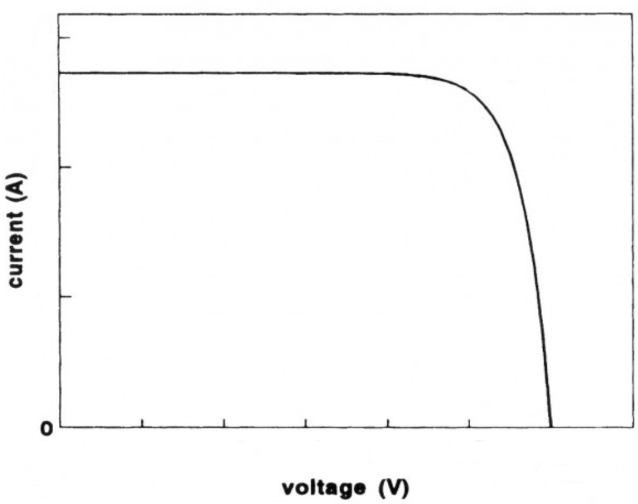
Readings are tabulated as follows:

Intensity	Resistance	Voltmeter Reading	Ammeter Reading
Maximum			

Table 8.1: V-Iand V-R characteristics

Table 8.2: V-I and V-R characteristics

Intensity	Resistance	Voltmeter Reading	Ammeter Reading
Minimum			



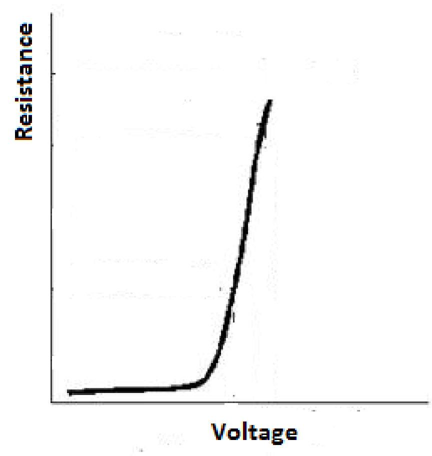


Fig. 8.2. Model Graph for V-I Characteristic **Fig. 8.3 Model Graph for V-R Characteristic**

Result:

The V-I and V-R Characteristics of the solar cell is studied.

9. MINI PROJECT – CONCEPT BASED DEMONSTRATION

Aim:

To construct the working model based on principles of physics, the opportunity to develop a range of skills and knowledge alreadylearnt to an unseen problem.

Objectives:

On successful completion of the mini project, the student will have developed skills in the following areas:

1. Design of experiments.
2. Experimental or computational techniques.
3. Searching the physical and related literature.
4. Communication of results in an oral presentation and in a report.
5. Working as part of a team.
6. Assessment of team members.

Assessment and Evaluation:

1. Each Class should have at least **eight groups**. Each group should have a **minimum of 5 members** or above and Maximum of **9members**.
2. Mini Project should be a **working model**. One page write-up about the project should be submitted as per the template provided by the class subject teacher.
3. **Department of Physics & Nanotechnology** will be organizing an event **TechKnow -15** to showcase these Mini Projects. All groups should present the working model along with the poster at the TechKnow-15.
4. Expert Committee will evaluate and select the best project from each class.
5. Certificates will be awarded for the best project during the event TechKnow - 15.
6. Marks for the project will be awarded under the following criteria.

S.No	Criteria	Marks
1.	Working model / Design	**5**
2.	Idea/ Concept / Novelty	**5**
3.	Presentation / Viva	**5**
4.	Usefulness / Application	**5**
	Total	**20**

SEMESTER II

		L	T	P	C
15PY102L	**MATERIALS SCIENCE**	**2**	**0**	**2**	**3**
	Total Contact Hours - 30				
	Prerequisite				
	Nil				

PURPOSE
The course introduces several advanced concepts and topics in the rapidly evolving field of material science. Students are expected to develop comprehension of the subject and to gain scientific understanding regarding the choice and manipulation of materials for desired engineering applications.

INSTRUCTIONAL OBJECTIVES	
1.	To acquire basic understanding of advanced materials, their functions and properties for technological applications
2.	To emphasize the significance of materials selection in the design process
3.	To understand the principal classes of bio-materials and their functionalities in modern medical science
4.	To get familiarize with the new concepts of Nano Science and Technology
5.	To educate the students in the basics of instrumentation, measurement, data acquisition, interpretation and analysis

List of Experiments:

1. Determination of resistivity and band gap for a semiconductor material – Four probe method / Post-office box
2. Determination of Hall coefficient for a semiconducting material
3. To study V-I characteristics of a light dependent resistor (LDR)
4. Determination of energy loss in a magnetic material – B-H curve
5. Determination of paramagnetic susceptibility – Quincke's method
6. Determination of dielectric constant for a given material
7. Calculation of lattice cell parameters – X-ray diffraction
8. Measurement of glucose concentration – Electrochemical sensor
9. Visit to Advanced Material Characterization Laboratory (Optional)

References

1. Thiruvadigal. J. D., Ponnusamy,S..Sudha.D. and Krishnamohan M., "Materials Science" SSS Publication, Chennai, 2015.

1(a). Band Gap Determination using Post Office Box

Aim

To find the band gap of the material of the given thermistor using post office box.

Apparatus Required

Thermistor, thermometer, post office box, power supply, galvanometer, insulating coil and glass beakers.

Principle and formulae

(1) Wheatstone's Principle for balancing a network $\frac{P}{Q} = \frac{R}{S}$

Of the four resistances, if three resistances are known and one is unknown, the unknown resistance can be calculated.

(2) The band gap for semiconductors is given by,

$$Eg = 2k\left(\frac{2.303\, log_e R_T}{1/T}\right)$$

where k = Boltzmann constant = 1.38×10^{-23} J/K

R_T = Resistance at T K

Procedure

1. The connections are given as in the Fig. 6.1(a).1. Ten ohm resistances are taken in P and Q.
2. Then the resistance in R is adjusted by pressing the tap key, until the deflection in the galvanometer crosses zero reading of the galvanometer, say from left to right.
3. After finding an approximate resistance for this, two resistances in R, which differ by 1 ohm, are to be found out such that the deflections in the galvanometer for these resistances will be on either side of zero reading of galvanometer.
4. We know $R_T = \frac{Q}{P} \times R = \frac{10}{10} \times R_1 \; or \; (R_1 + 1)$.This means that the resistance of the thermistor lies between R_1 and (R_1+1). Then keeping the resistance in Q the same, the resistance in P is changed to 100 ohm.
5. Again two resistances, which differ by one ohm are found out such that the deflections in the galvanometer are on the either side of zero. Therefore the actual resistance of thermistor will be between $\frac{R_2}{10}$ and $\frac{R_2 + 1}{10}$.

Table 1.1(a) To find the resistance of the thermistor at different temperatures

Temp. of thermistor T = t+273	$\frac{1}{T}$	Resistance in P	Resistance in Q	Resistance in R	Resistance of the thermistor $R_T = \frac{P}{Q} \times R$	2.303 $\log_{10} R_T$
K	K^{-1}	ohm	ohm	Ohm	ohm	ohm

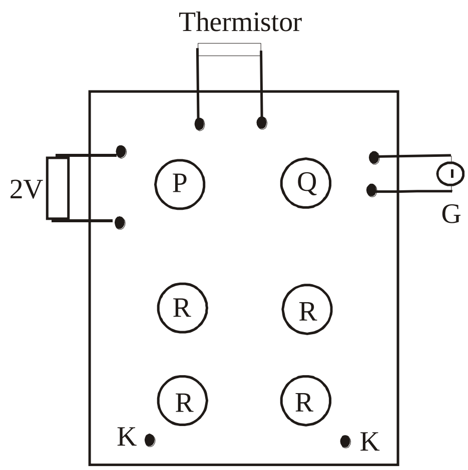


Fig 1.1(a) Post Office Box - Circuit diagram

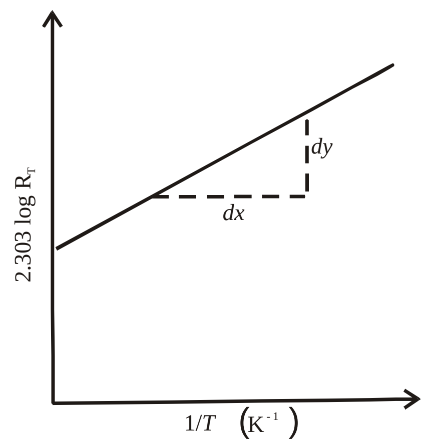


Fig 1.2(a) Model Graph

Observation

From graph, slope = (dy / dx) = ……

Calculation

Band gap, $E_g = 2k(dy / dx)$ **=…..**

6. Then the resistance in P is made 1000 ohms keeping same 10 ohms in Q. Again, two resistances R and (R+1) are found out such that the deflection in galvanometer changes its direction. Then the correct resistance.

$$= R_T = \frac{10}{1000}(R) \text{ (or)}$$

$$= R+1 = 0.01R \text{ (or) } 0.01(R+1)$$

7. Thus, the resistance of the thermistor is found out accurately to two decimals, at room temperature. The lower value may be assumed to be R_T (0.01R).

8. Then the thermistor is heated, by keeping it immersed in insulating oil. For every 10 K rise in temperature, the resistance of the thermistor is found out, (i.e) R_T's are found out. The reading is entered in the tabular column.

Graph

A graph is drawn between $\frac{1}{T}$ in X axis and 2.303 log R_T in Y axis where T is the temperature in K and R_T is the resistance of the thermistor at TK. The graph will be as shown in the Fig.6.1(a).2.

Band gap (Eg)=2k $\times$ slope of the graph = $2k\times\ (\frac{dy}{dx})$

where K = Boltzman's constant.

Result

The band gap of the material of the thermistor = ………eV.

1(b).Resistivity Determination for a Semiconductor Wafer using Four Probe Method

Aim

To determine the energy band gap of a semiconductor (Germanium) using four probe method.

Apparatus Required

Probes arrangement (it should have four probes, coated with zinc at the tips). The probes should be equally spaced and must be in good electrical contact with the sample), Sample (Germanium or silicon crystal chip with non-conducting base), Oven (for the variation of temperature of the crystal from room temperature to about 200°C), A constant current generator (open circuit voltage about 20V, current range 0 to 10mA), Milli-voltmeter (range from 100mV to 3V), Power supply for oven Thermometer.

Formula

The energy band gap, Eg., of semi-conductor is given by

$$E_g = 2k_B \frac{2.3026 \times log_{10} \rho}{1/T} \text{ in } eV$$

where k_B is Boltzmann constant equal to 8.6×10^{-5} eV / kelvin , and ρ is the resistivity of the semi-conductor crystal given by

$$\rho = \frac{\rho_0}{f(W/S)} \text{ where } \rho_0 = \frac{V}{I} \times 2\pi s \; ; \; \rho = \frac{V}{I}(0.213)$$

Here, s is distance between probes and W is the thickness of semi-conducting crystal. V and I are the voltage and current across and through the crystal chip.

Procedure

1. Connect one pair of probes to direct current source through milliammeter and other pair to millivoltmeter.
2. Switch on the constant current source and adjust current I, to a described value, say 2 mA.
3. Connect the oven power supply and start heating.
4. Measure the inner probe voltage V, for various temperatures.

Graph

Plot a graph in $\left(\frac{10^3}{T}\right)$ and $\log_{10}\rho$ as shown in Fig.6.1(b).2. Find the slope of the curve $\frac{AB}{BC} = \frac{\log_{10} \rho}{10^3/T}$. So the energy band gap of semiconductor (Germanium) is given by

$$E_g = 2k \times \frac{2.3026 \times \log_{10} \rho}{1/T}$$

$$= 2k \times 2.3026 \times \frac{AB}{CD} \times 1000 = 2 \times 8.6 \times 10^{-5} \times 2.3026 \times \frac{AB}{CD} \times 1000 eV = 0.396 \times \frac{AB}{CD} eV$$

Table 1.1(b) To determine the resistivity of the semi-conductor for various temperatures:

Current (I) = …………mA

S.No.	Temperature		Voltage (V)	Resistivity ρ (ohm. cm)	10^{-3}/ T	$Log_{10}\rho$
	in°C	in K	(Volts)		(K)	

Observations:

Distance between probes(s) = ……………………..mm

Thickness of the crystal chip (W) = ……………………mm

current (I) = ………………..mA

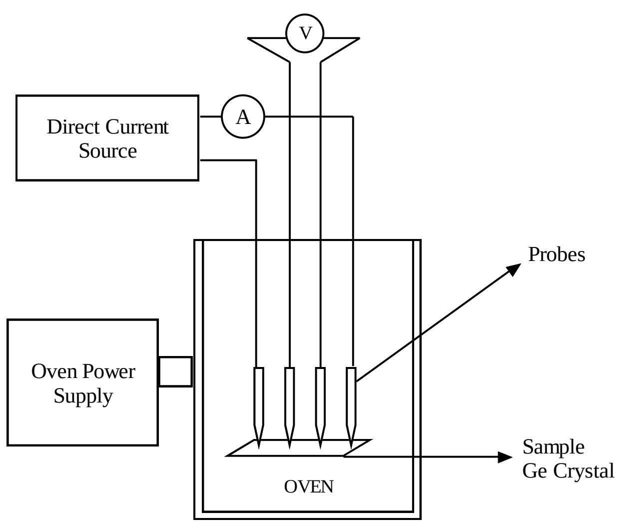


Fig 1.1(b) Four Probe Setup

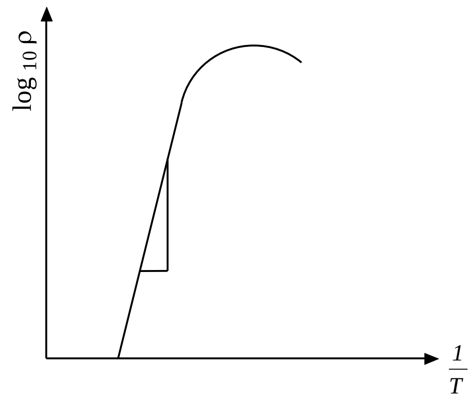


Fig 1.2(b) Model Graph

Result

Energy band gap for semiconductor (Germanium) is E_g =….eV

Source of error and precautions

1. The resistivity of the material should be uniform in the area of measurement.
2. The surface on which the probes rest should be flat with no surface leakage.
3. The diameter of the contact between the metallic probes and the semiconductor crystal chip should be small compared to the distance between the probes.

2. Determination of Hall Coefficient and carrier type for a Semi-conducting Material

Aim

To determine the hall coefficient of the given n type or p-type semiconductor

Apparatus Required

Hall probe (n type or p type), Hall effect setup, Electromagnet, constant current power supply, gauss meter etc.,

Formulae

i) Hall coefficient (R_H) $= \dfrac{V_H . t}{IH} \times 10^{8}\,\text{cm}^3\,\text{C}^{-1}$

where V_H = Hall voltage (volt)

t = Thickness of the sample (cm)

I = Current (ampere)

H = Magnetic filed (Gauss)

ii) Carrier density (n) $= \dfrac{1}{R_H\, q}\ \text{cm}^{-3}$

where R_H = Hall coefficient ($\text{cm}^3\,\text{C}^{-1}$)

q = Charge of the electron or hole (C)

iii) Carrier mobility (μ) $= R_H \sigma\ \text{cm}^2\text{V}^{-1}\ \text{s}^{-1}$

where R_H = Hall coefficient (cm^3C^{-1})

σ = Conductivity ($\text{C V}^{-1}\ \text{s}^{-1}\ \text{cm}^{-1}$)

Principle

Hall effect: When a current carrying conductor is placed in a transverse magnetic field, a potential difference is developed across the conductor in a direction perpendicular to both the current and the magnetic field.

Table 2.1 Measurement of Hall coefficient

Current in the Hall effect setup = ----------mA

Current in the constant current power supply (A)	Magnetic field (H) (Gauss)	Hall Voltage (V_H) (volts)	Hall coefficient (R_H) $cm^3\ C^{-1}$

Observations and Calculations

(1) Thickness of the sample = t = cm

(2) Resistivity of the sample = ρ = $V\ C^{-1}\ s\ cm$

(3) Conductivity of the sample = σ = $CV^{-1} s^{-1}\ cm^{-1}$

(4) The hall coefficient of the sample = $R_H = \frac{V_H . t}{IH} \times 10^{8}$

= -------------

(5) The carrier density of the sample = $n = \frac{1}{R_H q}$

= -------------

(6) The carrier mobility of the sample = $R_H \sigma$

= ---------------

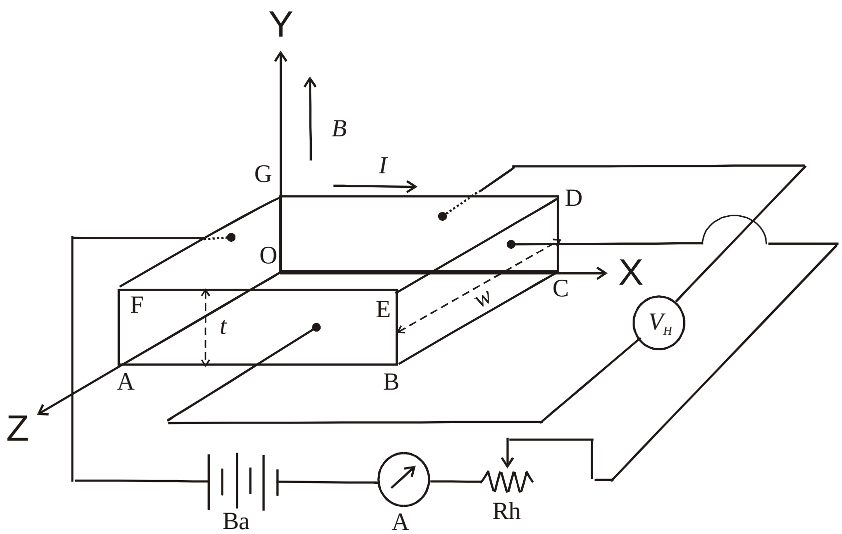


Fig 2.1 Hall Effect Setup

Procedure

1. Connect the widthwise contacts of the hall probe to the terminals marked as 'voltage' (i.e. potential difference should be measured along the width) and lengthwise contacts to the terminals marked (i.e. current should be measured along the length) as shown in fig.
2. Switch on the Hall Effect setup and adjust the current say 0.2 mA.
3. Switch over the display in the Hall Effect setup to the voltage side.
4. Now place the probe in the magnetic field as shown in fig and switch on the electromagnetic power supply and adjust the current to any desired value. Rotate the Hall probe until it become perpendicular to magnetic field. Hall voltage will be maximum in this adjustment.
5. Measure the hall voltage and tabulate the readings.
6. Measure the Hall voltage for different magnetic fields and tabulate the readings.
7. Measure the magnetic field using Gauss meter
8. From the data, calculate the Hall coefficient, carrier mobility and current density.

Result

1. The Hall coefficient of the given semi conducting material =
2. The carrier density =
3. The carrier mobility =

3. To study V-I Characteristics of a Light Dependent Resistor (LDR)

Aim

To measure the photoconductive nature and the dark resistance of the given light dependent resistor (LDR) and to plot the characteristics of the LDR.

Apparatus Required

LDR, Resistor (1 kΩ), ammeter (0 – 10 mA), voltmeter (0 – 10 V), light source, regulated power supply.

Formula

By ohm's law, $V = IR$ (or) $R = \dfrac{V}{I}$ ohm

where R is the resistance of the LDR (i.e) the resistance when the LDR is closed. V and I represents the corresponding voltage and current respectively.

Principle

The photoconductive device is based on the decrease in the resistance of certain semiconductor materials when they are exposed to both infrared and visible radiation.

The photoconductivity is the result of carrier excitation due to light absorption and the figure of merit depends on the light absorption efficiency. The increase in conductivity is due to an increase in the number of mobile charge carriers in the material.

Procedure

1. The connections are given in as shown in Fig. 6.3.1.
2. The light source is switched on and made to fall on the LDR.
3. The corresponding voltmeter and ammeter readings are noted.
4. The procedure is repeated by keeping the light source at different distances from the LDR.
5. A graph is plotted between resistance and distance of LDR from the light source.
6. The LDR is closed and the corresponding voltmeter and ammeter readings are noted. The value of the dark resistance can be calculated by Ohm's law.

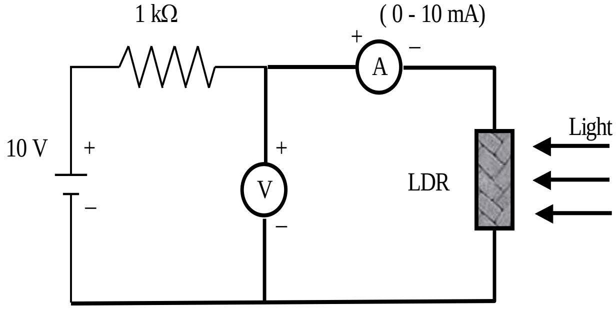


Fig. 3.1 Circuit diagram

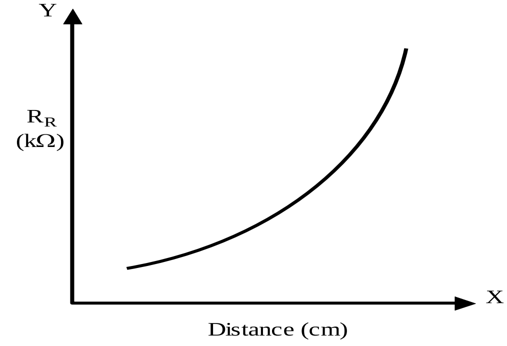


Fig.3.2 Model graph

Observation

Voltmeter reading when the LDR is closed = …… V

Ammeter reading when the LDR is closed = ……. A

Dark resistance = $R = \frac{V}{I}$ = **……. ohm**

Table 3.1 To determine the resistances of LDR at different distances

S.No	Distance (cm)	Voltmeter reading (V) volt	Ammeter reading (I) mA	R_R kΩ

Result

1. The characteristics of LDR were studied and plotted.
2. The dark resistance of the given LDR = …….. ohm

4.Determination of Energy Loss in a Magnetic Material – B-H Curve

Aim

(i) To trace the B-H loop (hysteresis) of a ferrite specimen (transformer core) and

(ii) To determine the energy loss of the given specimen.

Apparatus Required

Magnetizing coil, CRO, given sample of ferrite etc.,

Principle

The primary winding on the specimen, when fed to low a.c. voltage (50 Hz), produces a magnetic field H of the specimen. The a.c. magnetic field induces a voltage in the secondary coil. The voltage across the resistance R_1, connected in series with the primary is proportional to the magnetic field and is given to the horizontal input of CRO. The induced voltage in the secondary coil, which is proportional to dB/dt (flux density), is applied to the passive integrating circuit. The output of the integrator is now fed to the vertical input of the CRO. Because of application of a voltage proportional to H to the horizontal axis and a voltage proportional to B to the vertical axis, the loop is formed as shown in figure.

Formula

$$\text{Energy loss} = \frac{N_1}{N_2} \times \frac{R_2}{R_1} \times \frac{C_2}{AL} \times S_V\, S_H \times \text{Area of loop} \qquad \text{Unit: Joules / cycle / unit vol.}$$

where N_1 = number of turns in the Primary

N_2 = number of turns in the Secondary

R_1 = Resistance between D to A or D to B or D to C

R_2 = Resistance between upper S and V (to be measured by the student on B-H unit)

C_2 = Capacitance

A = Area of cross section = w × t (m)

L = Length of the specimen =2 (length + breadth) (m)

Table 4.1 To find width of the transformer core (w)

LC = …cm

S.No.	MSR	VSC	TR = MSR + VSC × LC
Unit	(cm)	(div)	(cm)

Mean (w) = ………………10^{-2} m

Table 4.2 To find thickness of the transformer core (t)

LC =… cm

S.No.	MSR	VSC	TR = MSR + VSC × LC
Unit	(cm)	(div)	(cm)

Mean (t) = ………………10^{-2} m

Observations

N_1 = Number of turns in the Primary = 200 turns

N_2 = Number of turns in the Secondary = 400 turns

R_2 = Resistance between upper S and V = 4.7 kilo-ohm

C_2 = Capacitance = 4.7μF

A = Area of cross section (w × t) =… m^2

L = Length of the specimen = 2(length + breadth) = … m

w = Width of the transformer core =… m

t = Thickness of the specimen =… m

R_1 = Resistance between D to A or D to B or D to C =

S_v = Vertical sensitivity of CRO =

S_H = Horizontal sensitivity of CRO =

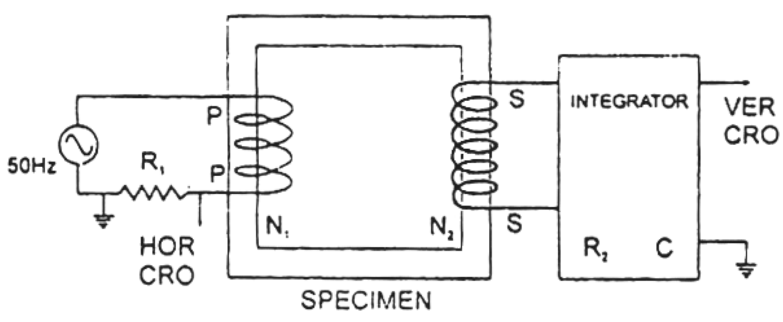


Fig 4.1 Experimental Arrangement

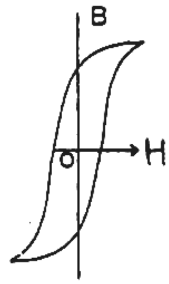


Fig 4.2 Hysteresis Loop

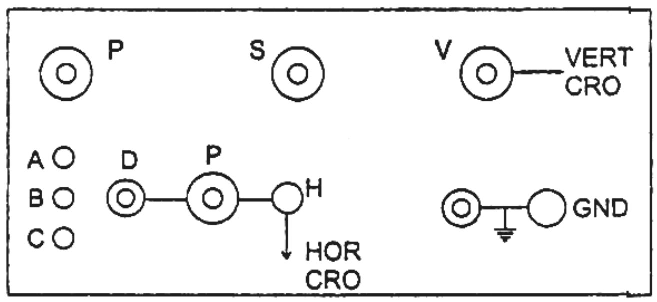


Fig 4.3 Top view of BH curve Unit

Table 4.3 To find breadth of the transformer core (w)

LC = …cm

S.No.	MSR	VSC	TR = MSR + VSC X LC
Unit	(cm)	(div)	(cm)

Mean (b) = ………………10^{-2} m

Table 4.4 To find length of the transformer core (l)

LC =… cm

S.No.	MSR	VSC	TR = MSR + VSC × LC
Unit	(cm)	(div)	(cm)

Mean (l) = ………………10^{-2} m

Procedure

1. Choose appropriate resistance values by connecting terminal D to either A,B or C.
2. Connect the primary terminals of the specimen to P,P and secondary to S, S terminals.
3. Calibrate the CRO.
4. Adjust the CRO to work on external mode. The time is switched off. Adjust horizontal and vertical position controls such that the spot is at the centre of the CRO screen.

5. Connect terminal marked GND to the ground of the CRO.

6. Connect terminal H to the horizontal input of the CRO.

7. Connect terminal V to the vertical input of the CRO.

8. Switch ON the power supply of the unit. The hysteresis loop is formed.

9. Adjust the horizontal and vertical gains such that the loop occupies maximum area on the screen of the CRO. Once this adjustment is made, do not disturb the gain controls.

10. Trace the loop on a translucent graph paper. Estimate the area of loop.

11. Remove the connections from CRO without disturbing the horizontal and vertical gain controls.

12. Determine the vertical sensitivity of the CRO by applying a known AC voltage, say 6V (peak to peak). If the spot deflects x cm, for 6V the sensitivity = $(6/x \times 10^{-2}$ volts / metre. Let it be S_v.

13. Determine the horizontal sensitivity of the CRO by applying a known AC voltage, say 6V (peak to peak). Let the horizontal sensitivity be S_H volts / metre.

14. The energy loss is computed from the given formula.

Result

Energy loss of the transformer core is given as _____________ Joules/cycle/unit vol.

5. Determination of Paramagnetic Susceptibility – Quincke's Method

Aim

To measure the susceptibility of paramagnetic solution by Quincke's tube method.

Apparatus Required

Quincke's tube, Travelling microscope, sample ($FeCl_3$ solution), electromagnet, Power supply, Gauss meter.

Principle

Based on molecular currents to explain Para and diamagnetic properties magnetic moment to the molecule and such substances are attracted in a magnetic filed are called paramagnetics. The repulsion of diamagnetics is assigned to the induced molecular current and its respective reverse magnetic moment**.**

The force acting on a substance, of either repulsion or attraction, can be measured with the help of an accurate balance in case of solids or with the measurement of rise in level in narrow capillary in case of liquids.

The force depends on the susceptibility χ, of the material, i.e., on ratio of intensity of magnetization to magnetizing field I/H. If the force on the substance and field are measured the value of susceptibility can be calculated.

Formula

The susceptibility of the given sample is found by the formula

$$\chi = \frac{2(\rho - \sigma)gh}{H^2} \text{ kg m}^{-1}\text{ s}^{-2}\text{ gauss}^{-2}$$

Where ρ is the density of the liquid or solution (kg/m^3)

σ is the density of air (kg/ m^3)

g is the acceleration due to gravity (ms^{-2})

h is the height through which the column rises (m)

H is the magnetic field at the centre of pole pieces (Gauss)

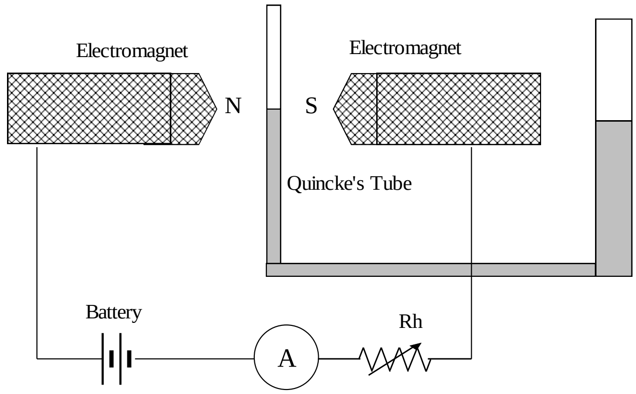


Fig. 5.1 Quincke's Setup

Table 5.1 To find the rise in the capillary tube of the solution:

Microscopic reading without field (h_1) = ….. cm

LC = … cm

TR = MSR + (VSC × LC)

S.No.	Current (i)	Field (H)	Travelling microscope reading (h_2)			Difference $h = h_1 \sim h_2$	h / H^2
	Ampere	Gauss	MSR (cm)	VSC (div)	TR (cm)	$\times 10^{-2}$ m	(m^{-1})

Mean h/H^2 = …………….

Observation:

ρ = density of the liquid or solution = …..kg/m^3

σ = density of air = … kg/ m^3

Calculation:

The magnetic susceptibility of the given solution $\chi = \frac{2(\rho - \sigma)gh}{H^2}$

Procedure

1. The apparatus consists of U-shaped tube known as Quincke's tube. One of the limbs of the tube is wide and the other one is narrow.
2. The experimental liquid or the solution ($FeCl_3$) is filled in the tube in such a way that the meniscus of the liquid in the narrow limb is at the centre of the magnetic field as shown in the figure.
3. The level of the liquid in the narrow tube is read by a traveling microscope when the magnetic field is off (h_1).
4. The magnetic field is switched on by switching on the electromagnet. Adjust the regulator knob available with the power supply to the electromagnet and fix the current to be 0.3A. The raised level of the column is read with the traveling microscope and noted in the table as (h_2).
5. The experiment is repeated by varying the field by changing the current insteps of 0.3 A upto the maximum and each reading is noted.
6. To determine the magnetic field (H), the hall probe flux meter (Gauss meter) is used.
7. The flat portion of the hall probe is placed perpendicular to the magnetic field i.e. between the pole pieces at the center parallel to the poles.
8. Switch off the electromagnet power supply. By adjusting, the gauss meter knob and fix the field to be zero.
9. Switch on the electromagnet and adjust the current to be 0.3A. Note the field value from the gauss meter. Repeat the same as before till attaining the maximum current and note the reading in the table.
10. Calculate the magnetic susceptibility using the above formula.

Result

The magnetic susceptibility of the given sample = …………… kg m^{-1} s^{-2} $gauss^{-2}$

6. Dielectric Constant Measurement

Aim

To determine the dielectric constant of the given sample at different temperatures.

Apparatus required

The given sample, capacitance meter, dielectric sample cell, digital temperature indicator etc.

Formula

1. The dielectric constant of the sample is given by,

$\varepsilon_r = C / C_0$ (No unit)

where C = capacitance of the sample (farad)

C_0 = Capacitance of the air capacitor having the same area and thickness as the sample (farad)

2. The capacitance of air capacitor is given by,

$$C_0 = \frac{\varepsilon_0 A}{d} \text{(farad)}$$

where ε_0 = permittivity of free space

= 8.854×10^{-12} farad / metre

A = area of the plates of the capacitor

($A = \pi r^2$: r = radius of the sample)

d = thickness of the sample (or) distance between the plates (m)

Principle

The capacitance of a capacitor increases when it is filled with an insulating medium. The increase in the capacitance depends on the property of the medium, called dielectric constant (ε). It can be measured using either static or alternating electric fields. The static dielectric constant is measured with static fields or with low frequency ac fields. At higher frequencies, values of dielectric constant become frequency dependent. The dielectric constant varies with temperature also.

Procedure

1. The given dielectric sample inside the dielectric cell in its position without forming air gap between the plates of the sample holder.

2. Connect the thermocouple leads to a digital temperature indicator to measure the temperature of the dielectric cell

3. Also, connect the capacitance meter to the dielectric cell

4. Connect the heater terminals of the dielectric cell to ac mains through a dimmerstat.

5. At room temperature, measure the capacitance of the sample using capacitances meter.

6. Now switch on the heater and measure the capacitance of the sample at different temperature (in steps of 10°C starting from room temperature).

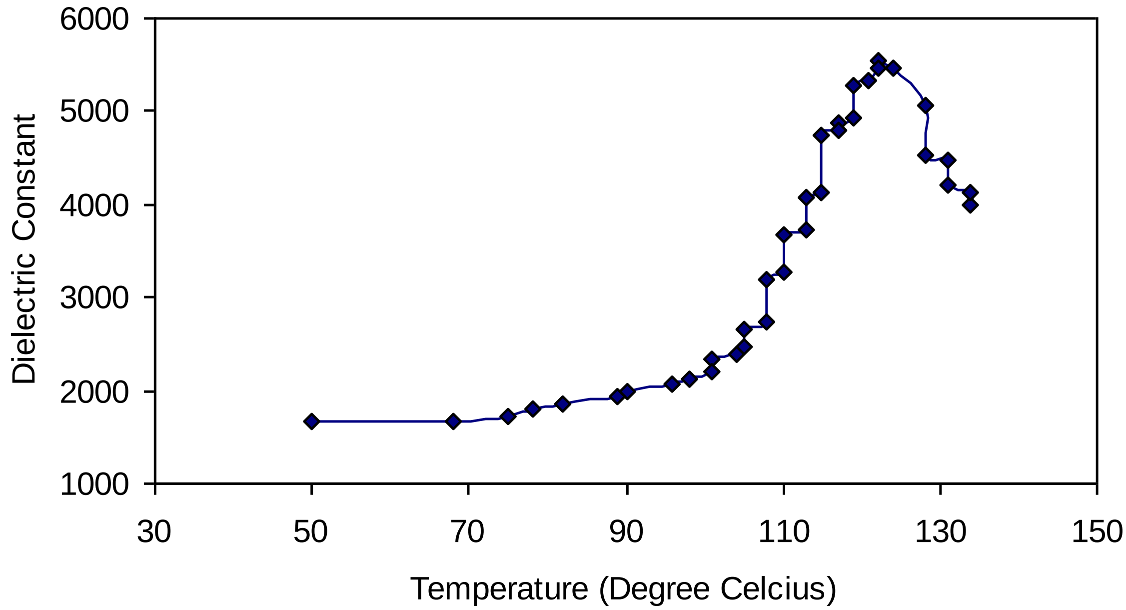


Fig. 6.1 Dielectric Constant versus Temperature for barium titanate

Table 6.1 Determination of dielectric constant of the sample:

Sl.No.	**Temperature (°C)**	**Capacitance (Farad)**	**Dielectric constant** $\left(\varepsilon_r = \frac{C}{C_0}\right)$

Observation

The radius of the sample (r) = ………………….m

The thickness of the sample (d) =…………………..m

Calculation

The area of the plates of the capacitor = πr^2 =…….. m^2

The capacitance of the air capacitor,

$$C = \frac{\varepsilon_0 A}{d} = \text{..........} \; farad$$

The dielectric constant of the sample

$$\varepsilon_n = \frac{C}{C_0}$$

7. Measure the thickness of the sample (*d*) using the micrometer screw attached in the sample cell
8. Measure the diameter of the sample using a vernier caliper and determine the radius of the sample
9. Calculate the capacitance of the air capacitor using, the relation

$$C_0 = \frac{\varepsilon_0 (\pi r^2)}{d}$$

10. Calculate the dielectric constant of the sample at different temperatures using the relation.

$$\varepsilon_r = \frac{C}{C_0}$$

and tabulate the readings in the table

11. Plot a graph by taking temperature along X axis and dielectric constant along Y axis.

Result

The dielectric constants of the given sample at different temperature are measured and a graph is plotted between the temperature and dielectric constant.

7. Calculation of Lattice Cell Parameters – X-ray Diffraction

Aim

The calculate the lattice cell parameters from the powder X-ray diffraction data.

Apparatus required

Powder X-ray diffraction diagram

Formula

For a cubic crystal

$$\frac{1}{d^2} = \frac{(h^2 + k^2 + l^2)}{a^2}$$

For a tetragonal crystal

$$\frac{1}{d^2} = \left\{ \frac{(h^2 + k^2)}{a^2} + \frac{l^2}{c^2} \right\}$$

For a orthorhombic crystal

$$\frac{1}{d^2} = \left(\frac{h^2}{a^2} \right) + \left(\frac{k^2}{b^2} \right) + \left(\frac{l^2}{c^2} \right)$$

The lattice parameter and interplanar distance are given for a cubic crystal as,

$$\mathrm{a} = \frac{\lambda}{2 \sin \theta} \sqrt{h^2 + k^2 + l^2} \ \text{Å}$$

$$\mathrm{d} = \frac{\mathrm{a}}{\sqrt{h^2 + k^2 + l^2}} \ \text{Å}$$

Where, a = Lattice parameter
d = Interplanner distance
λ = Wavelength of the CuKα radiation(1.5405)
h, k, l = Miller integers

Principle

Braggs law is the theoretical basis for X-ray diffraction.

$$(\sin^2 \theta)_{hkl} = (\lambda^2 / 4a^2)\ (h^2 + k^2 + l^2)$$

Each of the Miller indices can take values 0, 1, 2, 3, …. Thus, the factor ($h^2 + k^2 + l^2$) takes the values given in Table 6.7.1.

Table 7.1 Value of $h^2 + k^2 + l^2$ for different planes

h,k, l	$h^2 + k^2 + l^2$	***h,k, l***	$h^2 + k^2 + l^2$
100	1	300	9
110	2	310	10
111	3	311	11
200	4	322	12
210	5	320	13
211	6	321	14
220	8	400	16
221	9	410	17

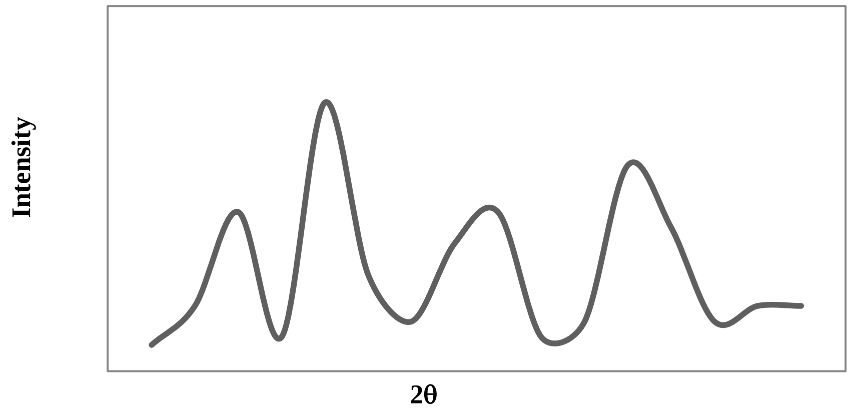


Fig. 7.1 XRD pattern

The problem of indexing lies in fixing the correct value of a by inspection of the $\sin^2\theta$ values.

Procedure:

From the 2θ values on a powder photograph, the θ values are obtained. The $\sin^2\theta$ values are tabulated. From that the values of $1 \times \frac{\sin^2\theta}{\sin^2\theta_{min}}, 2 \times \frac{\sin^2\theta}{\sin^2\theta_{min}}, 3 \times \frac{\sin^2\theta}{\sin^2\theta_{min}}$ are determined and are tabulated. The values of $3 \times \frac{\sin^2\theta}{\sin^2\theta_{min}}$ are rounded to the nearest integer. This gives the value of $\boldsymbol{h^2+k^2+l}$.From these the values of *h,k,l* are determined from the Table.6.7.1.

From the *h,k,l* values, the lattice parameters are calculated using the relation

$$a = \frac{\lambda}{2\sin\theta}\sqrt{h^2+k^2+l^2}\ \text{Å}$$

$$d = \frac{a}{\sqrt{h^2+k^2+l^2}}\ \text{Å}$$

Table 7.2 Value of $h^2 + k^2 + l^2$ for different planes

S. No	2θ	$sin^2\theta$	$1 \times \frac{sin^2\theta}{sin^2\theta_{min}}$	$2 \times \frac{sin^2\theta}{sin^2\theta_{min}}$	$3 \times \frac{sin^2\theta}{sin^2\theta_{min}}$	$h^2+k^2+l^2$	***hkl***	**a Å**	**d Å**

Table 7.3 Lattice determination

Lattice type	**Rule for reflection to be observed**
Primitive P	None
Body centered I	*hkl*: $h + k + l = 2n$
Face centered F	*hkl*: *h, k, l* either all odd or all even

Depending on the nature of the *h,k,l* values the lattice type can be determined.

Result:

The lattice parameters are calculated theoretically from the powder x-ray diffraction pattern.

8. Determination of Glucose Concentration using Sensor

Aim

To determine the glucose concentration in the solutions of different concentration using IR sensor.

Apparatus required

Infra red LED, Photodiode, Amplification circuit board, Microcontroller board of 16F877A , LCD, Power supply, Test Tube, Glucose – various concentrations like 10mg, 20mg, 30mg etc.

Principle

In this non invasive method, the infra red source and the detector work on the principle of transmission mode. Test tube with various glucose concentrations are placed in between an infrared light emitting diode and the photodiode. The infrared light source is transmitted through the test tube where there will be a change in optical properties of the light. Now the transmitted light is detected by the photodiode, which converts the light into electrical signal. This signal is sent to the microcontroller and output is displayed in the LCD.The experiment is repeated with different concentrations of glucose solutions and a graph is plotted between glucose concentration and voltage as indicated in Fig.6.8.2.

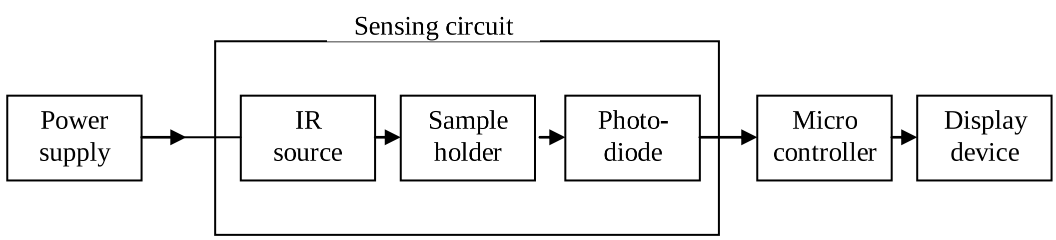


Fig.8.1 Schematic representation for determining glucose concentration

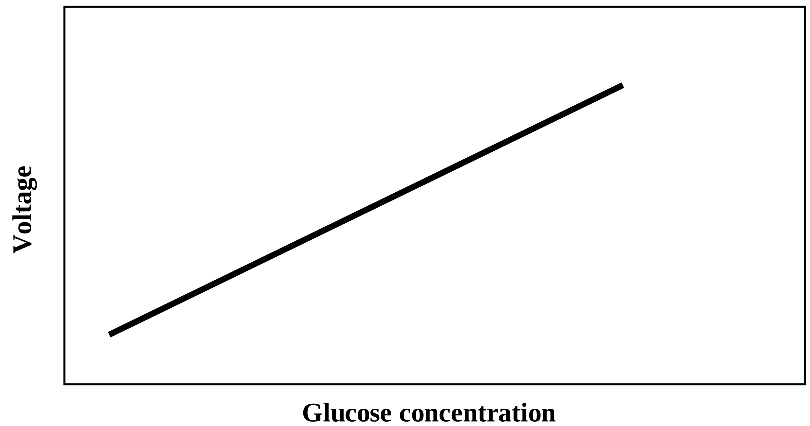


Fig. 8.2 Variation of voltage with glucose concentration

Table 8.1 Variation of voltage with glucose concentration

S.No	Glucose concentrations (mg)	Voltage obtained (V)

Result

The glucose concentrations have been determined and the variations of voltage with glucose concentration have been plotted.