Program Outcomes (POs)

Engineering Graduates will be able to:

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

Lab Objectives

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1	To develop scientific understanding of the physics concepts.
2	To develop the ability to explain the processes and applications related to science subjects.
3	To apply skills and knowledge in real life situations.
4	To improve the knowledge about the theory concepts of Physics learned in the class.
5	To improve the knowledge about the theory concepts of Physics learned in the class.
6	To develop understanding about inferring and predicting.

Lab Outcomes

At the end of the laboratory course students will be able to:		Action verb	Bloom's Level
BSL2013.1	Measure the uncertainty using statistical treatment of errors.	Measure	Applying Level 3
BSL2013.2	Determine the radius of curvature of a lens using Newton's ring set up.	Determine	Applying Level 3
BSL2013.3	Perform the experiment to understand the I-V characteristics of a photodiode.	Perform	Applying Level 3
BSL2013.4	Determine the concentration of charge carriers in a semiconductor material using Hall Effect expt.	Determine	Applying Level 3
BSL2013.5	Study the thermoelectric effect (seebeck-effect) using a thermocouple (Virtual Lab expt.)	Study	Applying Level 3
BSL2013.6	Perform experiments on nanotechnology using open source simulation software like Avogadro to draw different carbon structures.	Perform	Applying Level 3

Physics of Measurements and Sensors Lab

Sr. No	List of Experiments	LO Mapping
01.	Measurement of Uncertainty using Statistical Treatment of Errors.	LO 1
02.	Determine the radius of curvature of a lens using Newton's ring set up.	LO 2
03.	Measurement of Hall Voltage.	LO 4
04.	Carrier concentration using Hall Effect.	LO 4
05.	Measuring distance using ultrasonic distance meter flow.	LO 3
06.	Calibration of PT100.	LO 5
07.	Calibration of J / K type thermocouple.	LO 5
08.	Simulation experiments based on nanotechnology using open source simulation.	LO 6
09.	I-V characteristic of photo diode.	LO 3
10.	Characteristics of LDR.	LO 3

Physics of Measurements and Sensors Lab

Index

Sr. No	Title of experiments	Pag e No.	Date of Performance	Date of Submission	Mark s	Sign
1.	Measurement of Uncertainty using Statistical Treatment of Errors.					
2.	Determine the radius of curvature of a lens using Newton's ring set up.					
3.	Perform the experiment to understand the I-V characteristics of a photodiode.					
4.	Determine the concentration of charge carriers in a semiconductor material using Hall Effect expt.					
5.	Study the thermoelectric effect (seebeck-effect) using a thermocouple (Virtual Lab expt.).					
6.	Perform experiments on nanotechnology using open source simulation software like Avogadro to draw different carbon structures					
7.	Measurement of Hall Voltage.					
8.	Measuring distance using ultrasonic distance meter flow.					
9.	Calibration of PT100.					
10.	Characteristics of LDR.					

INSTRUCTIONS FOR STUDENTS

➢ **General Information**

Some of the purpose of conducting experiments can be enumerated as below:

- To get familiarized with the basic components, measuring instruments, work-bench, and basic machines.
- Observing basic phenomena and characteristics of machine.
- Reporting and analyzing the observations.
- Verify observations, basic rules and understanding physical concepts.
- Hands-on experience on machines.
- Observing safety and developing group-working culture.

To make lab-experiments safe and effective, each student must obey the following rules.

➢ **Dress:**

- **Boys**: Loose clothes not allowed. Shirt should be tucked-in properly, shoes with rubber sole, slippers are not allowed in the lab.
- **Girls**: Skirts with large flares not permitted, shoes with the rubber sole, slippers are not allowed in the lab.

➢ **Attendance:**

- All students are required to attend and contribute adequately while performing experiments in the group. Performance will be judged based on experiments conducted, quality & punctual submission of the lab report for each experiment.
- Faculty will take the attendance. Failure to be present for an experiment will result in losing entire marks for the corresponding experiment. However, genuine cases may be considered to repeat the experiment.
- Students must not attend a different lab group/section from the one assigned at the beginning of the class (unless otherwise approved by the instructor).
- If a student misses a lab session due to unavoidable circumstances, can provide a legitimate proof as soon as possible, he/she may then be allowed by the lab instructor, to make-it-up with a different section.

➢ **Preparation and Performance:**

- Before leaving the laboratory, each student must ask the lab instructor for the experiment number to be conducted on the next lab turn, so that the students come prepared after reading and reviewing the reallocated experiment.
- Faculty might check your preparedness and understanding of the experiment and failure to satisfactory reply may de-bar you from conducting the experiments.
- Record your observations in the Lab Manual's observation tables and do the calculations within the space provided. Do not hesitate to clear any of your doubts

concerning the experiments.

- Leave the work place clean after you have finished with your experiments. Dismantle the circuit and put all the wires and equipment back at its original place.

➢ **General working discipline in the Lab:**

Students should strictly follow the instructions given below while working in the Lab:

1. Attendance in the laboratory is mandatory.
2. Students should wear an ID card issued by college around their neck when they are in lab.
3. Students will not be allowed after 5 minutes from the scheduled time.
4. No student will leave the Lab without permission.
5. Students should bring their Lab Manuals whenever they come in the lab.
6. Any confusion may be clarified from the faculty at the time of experimentation.
7. Students must maintain discipline and silence in the lab.
8. Students are to remain within their allotted experimental area.
9. Student should be attentive all the time.
10. Follow the instructions given by the faculty or course instructor.
11. Failure to obey safety rules may result in the disciplinary action.

➢ **Completion of Manual/journal**

- Manual/journal should be completed as per the guidelines and deadlines given by the subject teacher.
- Each student is required to complete the manual/journal well in time.
- Manual/journal should be neatly written and duly checked by the subject teacher.
- Questions given under the lab manual should be answered by students in the space provided in the lab manual.
- Individual comments/Notes must be written for the further improvement of the lab manual.

Name: -

Branch / Div: - Roll No: -

Experiment No: 01

TITLE: Measurement of Uncertainty using Statistical Treatment of Errors

Date of Performance:

Date of Completion:

Rubrics for Assessment of Experiment
Performance Indicators for assessing Lab Outcomes

Performance Indicator	Exceed Expectations (EE)	Meet Expectations (ME)	Below Expectations (BE)	Marks Obtained
Performance (03 marks)	*The entire experiment was performed within the assigned time with full attention. (03)*	*The entire experiment was executed on the deadline with less attention (02)*	*The entire experiment was performed beyond the assigned time. (01)*	
Readings, Calculations & Graphs (03 marks)	*All the readings taken are in the range. All figures & Graphs are correctly drawn & Calculations are done accurately (03)*	*All the readings taken are not in the range. All figures &, Graphs are correctly drawn but some important features are missing & Calculations are done incorrectly (02)*	*All the readings are beyond range. All figures & Graphs are poorly drawn & Calculations are done incorrectly (01)*	
Understanding (02 marks)	*Complete understanding of the aim of the experiment and the basic concepts (02)*	*Incomplete understanding of the aim of the experiment and the basic concepts (01)*	*Very less understanding of the aim of the experiment and the basic concepts (0.5)*	
Timely submission (02 marks)	*Very neat and complete write-ups submitted on the assigned day. (02)*	*Write-ups submitted late by 2-4 day (01)*	*Write-ups submitted late by 4-6 day (0.5)*	
Total Marks				

Experiment No. 1

Measurement of Uncertainty using Statistical Treatment of Errors

Aim: - To apply and understand statistical methods, including sample mean, sample standard deviation, population mean, population standard deviation, and principles of least squares.

Apparatus: - Pendulum (bob, inextensible string), Meter scale, Stopwatch and Clamp stand.

Diagram: -

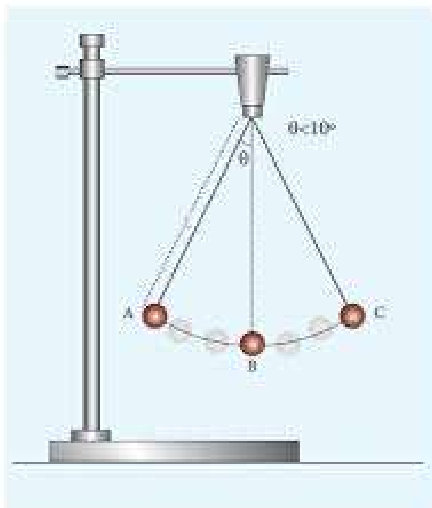


Figure 1: Schematic diagram of simple pendulum experiment

Formula:-

$$\boxed{T = 2\pi\sqrt{\frac{L}{g}}}$$

Where T - Time period of the simple pendulum

L - Length of the string

g - Acceleration due to gravity

Precaution: - Ensure that the pendulum oscillates in a vertical plane and that there is no rotational motion of the pendulum.

Procedure: -

1. Set up the simple pendulum with a fixed length (e.g., 50 cm).

2. Displace the pendulum slightly and release it to allow it to oscillate freely.

3. Measure the time for 10 complete oscillations using a stopwatch. Repeat this measurement five times and record the results.

4. Calculate the period of one oscillation (T) by dividing the recorded time for 10 oscillations by 10.

5. Repeat the experiment for three different lengths of the pendulum (e.g., 50 cm, 70 cm, 90 cm).

6. Record all observations.

Note:

The experiment has already been performed, and the data and observations are provided below. Utilize the given information to perform the statistical treatment of errors, including calculations of sample mean, sample standard deviation, population parameters, and least squares analysis. Complete the analysis and interpretation within the allotted 1-hour session.

Sample Mean and Sample Standard Deviation

A pendulum is set up to measure the acceleration due to gravity. The period of 10 oscillations is measured 5 times for a pendulum length of 50 cm. The following times (in seconds) were recorded:

12.1, 11.9, 12.0, 12.2, 12.1

a. Calculate the sample mean of the period of one oscillation.

b. Determine the sample standard deviation of the period.

Population Mean and Standard Deviation

1. Explain the difference between the sample mean and the population mean in the context of experimental physics.

2. If the entire population of measurements were taken, and the mean period is found to be 12.05 seconds with a standard deviation of 0.15 seconds, how does this compare to your sample calculations?

Principles of Least Squares

1. The period of a pendulum is related to its length by the formula: $T^2 = (4\pi^2/g)\, L$

The following data were recorded for three different lengths of the pendulum:

L (cm)	T (sec)	T^2 (sec ^{2})
50	1.41	
70	1.67	
90	1.90	

2. Calculate T^2 for each length.

3. Plot T^2 against L and determine the slope of the best-fit line using the least squares method.

4. Use the slope to calculate the acceleration due to gravity *g*.

Calculations: -

Result: -

	Estimated Value
Sample Mean (T_{MEAN})	
Sample Standard deviation (T_{STD})	
g (m/s^2) from slope	

Viva Questions:

1. Discuss the possible sources of error in the pendulum experiment and their impact on the results.

2. How do the sample standard deviation and the least squares method help in minimizing the effect of random errors?

Answers:

Name: -

Branch / Div: - Roll No: -

Experiment No: 02

TITLE: Newton's Ring Experiment

Date of Performance:

Date of Completion:

Rubrics for Assessment of Experiment
Performance Indicators for assessing Lab Outcomes

Performance Indicator	Exceed Expectations (EE)	Meet Expectations (ME)	Below Expectations (BE)	Marks Obtained
Performance (03 marks)	*The entire experiment was performed within the assigned time with full attention. (03)*	*The entire experiment was executed on the deadline with less attention (02)*	*The entire experiment was performed beyond the assigned time. (01)*	
Readings, Calculations & Graphs (03 marks)	*All the readings taken are in the range. All figures & Graphs are correctly drawn & Calculations are done accurately (03)*	*All the readings taken are not in the range. All figures &, Graphs are correctly drawn but some important features are missing & Calculations are done incorrectly (02)*	*All the readings are beyond range. All figures & Graphs are poorly drawn & Calculations are done incorrectly (01)*	
Understanding (02 marks)	*Complete understanding of the aim of the experiment and the basic concepts (02)*	*Incomplete understanding of the aim of the experiment and the basic concepts (01)*	*Very less understanding of the aim of the experiment and the basic concepts (0.5)*	
Timely submission (02 marks)	*Very neat and complete write-ups submitted on the assigned day. (02)*	*Write-ups submitted late by 2-4 day (01)*	*Write-ups submitted late by 4-6 day (0.5)*	
Total Marks				

Experiment No. 2

NEWTON'S RINGS

Aim: - To determine the radius of curvature of a plano-convex lens by obtaining Newton's rings pattern.

Apparatus: -

Traveling microscope, plane glass plate (or clean old photographic plate), Plano-convex lens of very large radius of curvature, condensing (focusing) lens of small focal length, sodium source (monochromatic source), magnifying lens, thin glass plate etc.

Theory:

Newton's rings are formed when a plano-convex lens of large radius of curvature is placed on a plane glass sheet. The combination forms a thin circular air film of variable thickness in all directions around the point of contact of the lens and the glass plate at O. If monochromatic light is allowed to fall normally (as shown in Figure 1) on the lens using the 45º inclined glass plate, and the film is viewed in reflected light, interference fringes are observed in the form of a series with concentric rings (as shown in Figure 2)

When the light is incident on the plano-convex lens, part of the light incident on the system is reflected from glass-to-air boundary (say at point D). The reminder of the light is transmitted through the air film .it is again reflected from the air-to-glass boundary (say from point J)

The two rays are (1 and 2) reflected from the top and bottom of the air film interfere with each other to produce darkness and brightness.

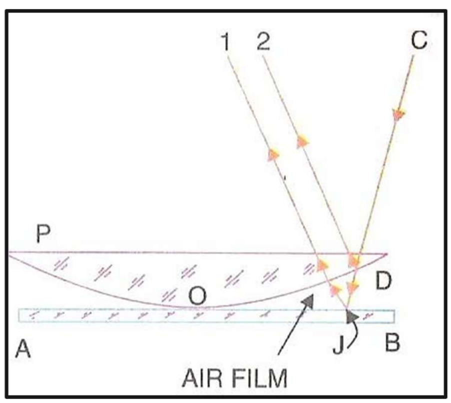


Figure 2: Newton's Rings Experiment

The condition for destructive interference is the same obtained from the air wedge experiment

$$2t = m\lambda$$

To determine the wavelength of the sodium light we use the following relation

$$r^2 = m\lambda R$$

(r) is the radius of the fringe.
(m) is the order of the ring.
(R) is the radius of curvature of the plano convex lens.
(λ) is the wave length of the used monochromatic light (sodium) in vacuum.

Experimental arrangement:

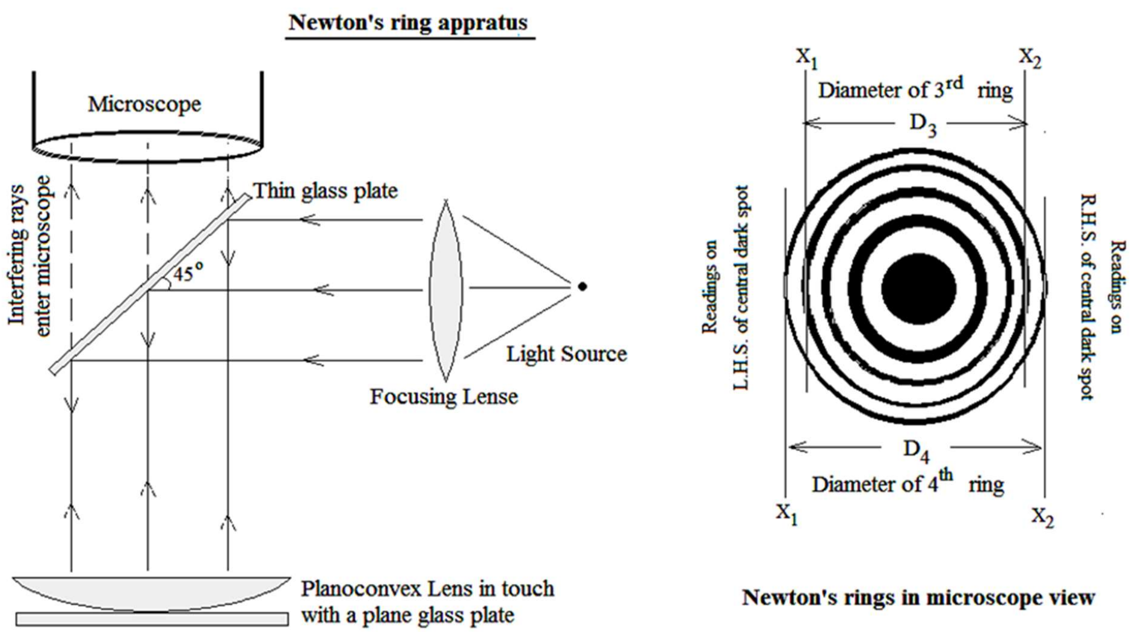


Figure 3: Formation of Newton's rings**.**

Formula: -

$$R = \frac{D_{n_2}^{\ 2} - D_{n_1}^{\ 2}}{4\,(n_2 - n_1)\,\lambda}$$

Where,

D_{n_1} **-**diameter of n_1^{th} dark ring & D_{n_2} **-** diameter of n_2^{th} dark ring.

λ - Wavelength of light used.

R **-** Radius of curvature of Plano convex lens.

Procedure: -

1) Arrange the apparatus as shown in figure. Take care that parallel light rays from source are incident on thin glass plate making angle of 45°. Collect the rays getting reflected from air film (between plano-convex lens & thick glass plate) in microscope. These rays interfere with each other to produce interference pattern in form of concentric rings.
2) Adjust the microscope vertically to focus interference rings. (In case some difficulty is experienced, the microscope may first focus upon the upper surface of thick plate and the lens is placed over it. Then move the traveling microscope above till the rings are seen clearly.)
3) In the view move to left side of central dark spot. Count the rings being crossed by vertical cross wire & go **beyond 10th ring**. Set horizontal motion of microscope on slow motion

screw.

4) Move microscope slowly & coincide the **vertical cross wire** tangentially on the 10th ring (dark ring) and note down reading on **horizontal scale**.
5) Move microscope slowly towards central dark spot to take readings for 9th, 8th … up to 3rd dark ring on left side of central dark spot.
6) Then further move the microscope gradually so that in view vertical cross wire crosses the central dark spot & then tangentially coincides with 3rd ring's edge on right side of central dark spot. Take the reading.
7) Move microscope slowly further to right of the central dark spot to take readings up to 10th dark ring.

CAUTION: Within set of readings if any ring is missed out while moving the microscope, NEVER go back with SLOW MOTION SCREW OF MICROSCOPE. Skip that reading & consider next ring.

Diagram:

Observations: -

(1) Total number of divisions on the horizontal vernier scale of traveling

microscope,

N = ______

(2) Value of smallest division on the horizontal main scale of traveling microscope

m = _______ cm.

(3) Least count of traveling microscope, L.C. = m / N = -------- cm.

Microscope reading = M.S.R. + (C.D. L.C.)*
M.S.R. - main scale reading, C.D. - coinciding division number

(4) Wavelength of light from sodium source = 5893 A°.

READ ON HORIZONTAL SCALE OF TRAVELING MICROSCOPE

Obs no.	Ring No. 'n'	Microscope reading with vertical crosswire coinciding with n^{th} dark ring edge on --		Diameter of n^{th} ring $D_n = \vert X_2 - X_1 \vert$ (cm)	D_n^2 (cm^2)
		left side of central spot 'X_1' cm	right side of central spot 'X_2 ' cm		
1.	10				
2.	9				
3.	8				
4.	7				
5.	6				
6.	5				
7.	4				
8.	3				

Graph: - Plot the graph of D_n^2 (on Y-axis) against 'n' serial no. of ring (on X-axis).

Calculations: -

From graph, slope = ___________ cm^2

$$R = \frac{D_{n_2}^{\ 2} - D_{n_1}^{\ 2}}{4\,(n_2 - n_1)\,\lambda} = \frac{slope}{4\,\lambda} = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \ cm$$

Result: - Radius of curvature of plano-convex lens, R = __________ m.

Viva Questions:

1. Why are the fringes circular?
2. How is the central spot in your experiment, bright or dark? Why?
3. Instead of reflected rays, if you look at transmitted rays, what do you expect to observe?

Answers: -

-

Name: -

Branch / Div: - Roll No: -

Experiment No: 03

TITLE: I-V Characteristics of a Photodiode.

Date of Performance:

Date of Completion:

Rubrics for Assessment of Experiment

Performance Indicators for assessing Lab Outcomes

Performance Indicator	Exceed Expectations (EE)	Meet Expectations (ME)	Below Expectations (BE)	Marks Obtained
Performance (03 marks)	*The entire experiment was performed within the assigned time with full attention. (03)*	*The entire experiment was executed on the deadline with less attention (02)*	*The entire experiment was performed beyond the assigned time. (01)*	
Readings, Calculations & Graphs (03 marks)	*All the readings taken are in the range. All figures & Graphs are correctly drawn & Calculations are done accurately (03)*	*All the readings taken are not in the range. All figures &, Graphs are correctly drawn but some important features are missing & Calculations are done incorrectly (02)*	*All the readings are beyond range. All figures & Graphs are poorly drawn & Calculations are done incorrectly (01)*	
Understanding (02 marks)	*Complete understanding of the aim of the experiment and the basic concepts (02)*	*Incomplete understanding of the aim of the experiment and the basic concepts (01)*	*Very less understanding of the aim of the experiment and the basic concepts (0.5)*	
Timely submission (02 marks)	*Very neat and complete write-ups submitted on the assigned day. (02)*	*Write-ups submitted late by 2-4 day (01)*	*Write-ups submitted late by 4-6 day (0.5)*	
Total Marks				

Experiment No-03

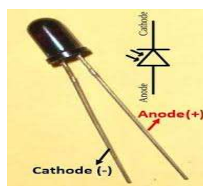
I-V CHARACTERISTICS OF PHOTODIODE

Aim: - To study the I-V characteristics of Photodiode.

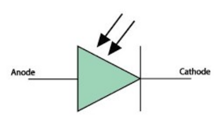
Apparatus: – A photodiode kit, connecting wires, source of light etc.

Theory: – Photodiode is a form of light-weight sensor that converts light energy into electrical voltage or current. Photodiode is a type of semi conducting device with PN junction. Between the p (positive) and n (negative) layers, an intrinsic layer is present. The photo diode accepts light energy as input to generate electric current.

It is also called as Photodetector, photo sensor or light detector. Photo diode operates in reverse bias condition i.e. the p-side of the photodiode is connected with negative terminal of battery (or the power supply) and n-side to the positive terminal of battery. Typical photodiode materials are Silicon, Germanium, Indium Gallium Arsenide Phosphide and Indium gallium arsenide. Few photo diodes will look like Light Emitting Diode (LED). It has two terminals as shown below. The smaller terminal acts as cathode and longer terminal acts as anode.



The symbol of the photodiode is similar to that of an LED but the arrows point inwards as opposed to outwards in the LED. The following image shows the symbol of a photodiode.



Circuit Diagram:

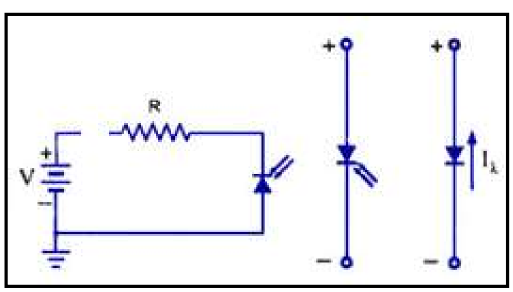


Figure 4: Circuit diagram of a photodiode.

Procedure:

1. Connect the circuit as shown in fig.

2. Note down corresponding current by varying voltage for a specified distance ('d'). Repeat the same procedure for different value of distance ('d').
3. Plot the graph distance (on X-axis) V/S. current (on Y-axis).

Observation Table: **Part: I (I-V-characteristics)**

Obs. No.	d = 10 cm		d = 15 cm		d = 20 cm		d = 25 cm		d = 30 cm	
	V_s (V)	I_r (μA)	V_s(V)	I_r(μA)	V_s(V)	I_r(μA)	V_s(V)	I_r(μA)	V_s (V)	I_r (μA)
1										
2										
3										
4										
5										
6										
7										
8										

Part: II

Procedure:

1. Connect the circuit as shown in fig.

2. Note down current for different values of distance keeping voltage constant.
3. Plot the graph distance (on X-axis) V/S current (on Y-axis).

Observation:

For V_s =

Obs. No.	d (cm)	$1/d^2$ (cm^{-2})	I_r (μA)
1			
2			
3			
4			
5			
6			

Graph: - For part I

Plot the graph of I_r (μA) against V_s (V)

For part II

Plot the graph of I_r (μA) against $1/d^2$ (cm^{-2})

Result:-

Conclusion: - The reverse bias current _______ with increasing intensity of light.

Viva Questions:

1. What is the difference between normal diode & photo diode?
2. What is the Principle of Photo diode?
3. V-I characteristic of Photo diode?
4. What are the application of Photo diode?

Answers:

Name: -

Branch / Div: - Roll No: -

Experiment No: 04

TITLE: Determination of Hall Voltage

Date of Performance:

Date of Completion:

Rubrics for Assessment of Experiment
Performance Indicators for assessing Lab Outcomes

Performance Indicator	Exceed Expectations (EE)	Meet Expectations (ME)	Below Expectations (BE)	Marks Obtained
Performance (03 marks)	*The entire experiment was performed within the assigned time with full attention. (03)*	*The entire experiment was executed on the deadline with less attention (02)*	*The entire experiment was performed beyond the assigned time. (01)*	
Readings, Calculations & Graphs (03 marks)	*All the readings taken are in the range. All figures & Graphs are correctly drawn & Calculations are done accurately (03)*	*All the readings taken are not in the range. All figures &, Graphs are correctly drawn but some important features are missing & Calculations are done incorrectly (02)*	*All the readings are beyond range. All figures & Graphs are poorly drawn & Calculations are done incorrectly (01)*	
Understanding (02 marks)	*Complete understanding of the aim of the experiment and the basic concepts (02)*	*Incomplete understanding of the aim of the experiment and the basic concepts (01)*	*Very less understanding of the aim of the experiment and the basic concepts (0.5)*	
Timely submission (02 marks)	*Very neat and complete write-ups submitted on the assigned day. (02)*	*Write-ups submitted late by 2-4 day (01)*	*Write-ups submitted late by 4-6 day (0.5)*	
Total Marks				

Experiment No. 04

HALL EFFECT EXPERIMENT

Aim:- To study Hall effect & determine Hall coefficient for the given sample in probe.

Apparatus:- Hall effect instrument, Hall probe *(sample - Indium Arsenide)*, etc.

Theory:- When a current carrying sample (metal or semiconductor) is kept in a homogeneous external magnetic field , then a potential difference called Hall voltage gets developed between the opposite faces. Direction of this Hall field is perpendicular to both applied magnetic field & the current through sample.

This effect occurs because, when the charge carriers move through sample for current conduction, they experience force due to magnetic field & they get deflected in direction perpendicular to both applied field & direction of motion of carriers.

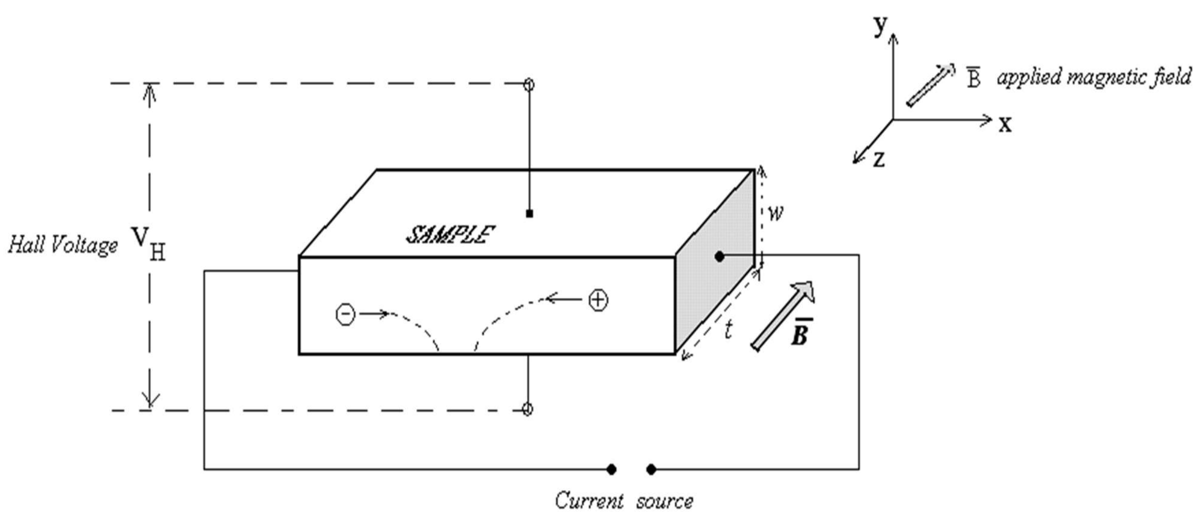


Figure 5 : Diagram illustrating the occurrence of Hall effect.

The drifting carriers start accumulating near the one surface of sample as shown in following diagram & this makes an electric potential getting developed between that surface & the opposite one. Thus the new electric field arises in the sample called Hall electric field which now exerts force on the carriers which happens to be in the opposite direction to that of magnetic field force. Thus, deflection in carriers path, accumulation of charges at surface continues till the magnetic field force dominates over hall field force. Gradually increasing charge accumulation makes Hall field stronger & stronger until it perfectly balances the force due to magnetic field. This is the saturation state & path of charge carriers do not deflect further. The voltage developed between the opposite faces of sample due to saturated accumulation of charges is then called Hall voltage.

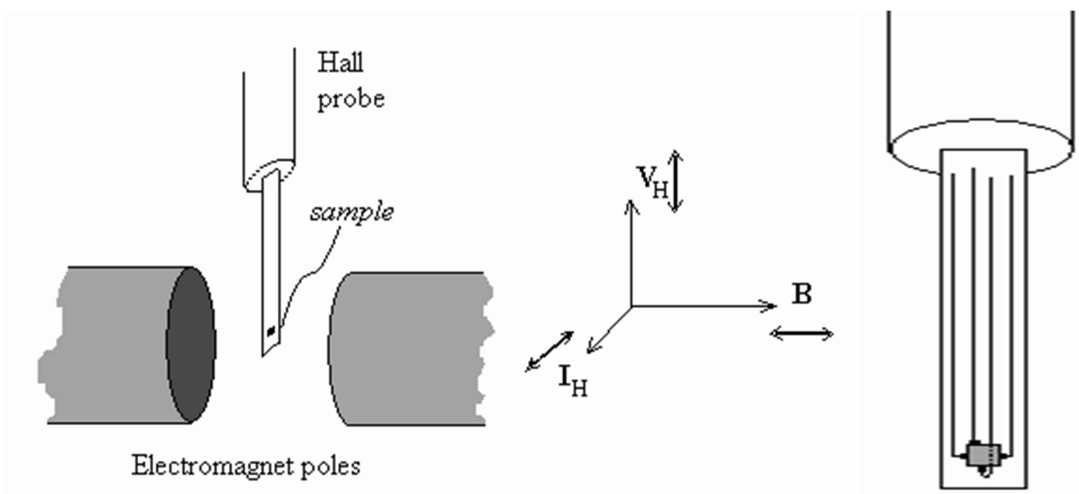
At saturation stage we get for hall field intensity, $E_H = \dfrac{BJ}{ne} = \dfrac{1}{ne} BJ = R_H\, BJ$

Here term $R_H = \dfrac{1}{ne}$ is termed as Hall coefficient. Thus, we get expression for Hall coefficient as $R_H = \dfrac{E_H}{BJ}$

But experimentally, $E_H = \dfrac{V_H}{w}$ & $J = \dfrac{I}{w.t}$

Hence $R_H = \dfrac{V_H}{B}\dfrac{t}{I}$ with 't' is the dimension of sample chip along direction of $\overline{B}$

Diagram:



Electrical connections for sample in the probe

Figure 6 : Experimental setup of Hall Effect.

Formula: Hall Coefficient of a sample in Hall Effect is given by $R_H = \dfrac{V_H\ t}{B.I}$

Where, V_H – Hall voltage measured across the sample

B – Applied magnetic field induction

I – Current flowing through sample

t – Thickness of sample along the direction of applied magnetic field

Procedure:

1. Maintain distance between the electromagnet pole pieces to a desired value (say 10 mm) using the spacers given with the kit. Set the electromagnet current to some desired value, say 300 mA, note down the current value in observations & write the corresponding magnetic flux from calibration chart. Do not disturb this throughout the experiment.
2. Set the Probe current at +/- 100 mA. Adjust ZERO control so that PROBE OUTPUT meter reads zero. Do not disturb this throughout the experiment.
3. Insert carefully the hall probe with fitting cap on it through the hole provided for fitting purpose. Hold it so that the probe faces are parallel to pole faces. Also, make sure that probe tip should lie at the centre of the poles. Do not disturb this arrangement throughout the experiment.
4. Now start applying various values of probe current & note down corresponding values of PROBE OUTPUT i.e. Hall voltage.
5. Use '+' as well as '–'values of probe currents.

Circuit Diagram:-

Observations:

- Distance between pole-pieces of electromagnet = _______
- Electromagnet current =____________
- Magnetic field present in the gap between poles, **B =**__________
- Thickness of sample along the field direction, **t =**______

Sr. No	**Sample Current 'I'** ***in mA***	**Hall Voltage 'V_H'** ***in mV***
1.	-60	
2.	-50	
3.	-40	
4.	-30	
5.	-20	
6.	-10	
7.	0	
8.	10	
9.	20	
10.	30	
11.	40	
12.	50	
13.	60	

Graph: Plot a graph of Hall voltage 'V_H' against sample current 'I'.

Calculations:

The slope of graph is

$$slope = \frac{V_H}{I} = \_\_\_\_\_\_\_\_\_\_$$

According to formula, Hall coefficient is given as,

$$R_H = \frac{V_H}{I}\frac{t}{B} = slope \cdot \frac{t}{B} = \text{-----------------------}$$

R_H = ___________________ m^3/Coulomb

From theory, we know that,

$R_H = \frac{1}{n.e}$ *where 'n'- majority carrier concentration & 'e'- carrier's charge*

Hence carrier concentration in given sample is

$$n = \frac{1}{R_H.e} = -------$$

= _______________ per m^3

Results:

For the given Hall probe sample (which is "Indium Arsenide"),

- Hall coefficient is R_H = ____________________
- Carrier concentration i.e. doping concentration is =_____________________

Viva Questions:

1. What will happen?
    - If sample is held parallel to magnetic field?
    - If electromagnet dipoles are brought closer?
    - If sample is rotated in 180° ?
    - If sample material is changed?
2. When will be the slope of graph?
    - Increasing?
    - Decreasing?
    - Changing sign?

Answers:

Name:-

Branch / Div: - Roll No:-

Experiment No: 05

TITLE: Thermoelectric Effect using Thermocouple

Date of Performance:

Date of Completion:

Rubrics for Assessment of Experiment
Performance Indicators for assessing Lab Outcomes

Performance Indicator	Exceed Expectations (EE)	Meet Expectations (ME)	Below Expectations (BE)	Marks Obtained
Performance (03 marks)	*The entire experiment was performed within the assigned time with full attention. (03)*	*The entire experiment was executed on the deadline with less attention (02)*	*The entire experiment was performed beyond the assigned time. (01)*	
Readings, Calculations & Graphs (03 marks)	*All the readings taken are in the range. All figures & Graphs are correctly drawn & Calculations are done accurately (03)*	*All the readings taken are not in the range. All figures &, Graphs are correctly drawn but some important features are missing & Calculations are done incorrectly (02)*	*All the readings are beyond range. All figures & Graphs are poorly drawn & Calculations are done incorrectly (01)*	
Understanding (02 marks)	*Complete understanding of the aim of the experiment and the basic concepts (02)*	*Incomplete understanding of the aim of the experiment and the basic concepts (01)*	*Very less understanding of the aim of the experiment and the basic concepts (0.5)*	
Timely submission (02 marks)	*Very neat and complete write-ups submitted on the assigned day. (02)*	*Write-ups submitted late by 2-4 day (01)*	*Write-ups submitted late by 4-6 day (0.5)*	
Total Marks				

Experiment No. 05

THERMOELECTRIC EFFECT USING THERMOCOUPLE

Aim: - To verify the relation between thermo-emf of a thermocouple and temperature difference between two hot junctions

Apparatus: Two beakers: one with ice kept in it and another with hot water bath, two wires of different metals, a thermometer, a burner, and a voltmeter.

Theory:

The conversion of temperature difference to electric current and vice-versa is termed as thermoelectric effect. In 1981, Thomas Johann Seebeck found that a circuit with two dissimilar metals with different temperature junctions would deflect a compass magnet. He realised that there was an induced electric current, which by Ampere's law deflect the magnet. In addition, electric potential or voltage due to the temperature difference can drive the electric current in the closed circuit.

To measure this voltage, one must use a second conductor material, which generates a different voltage under the same temperature gradient. Otherwise, if the same material is used for measurement, the voltage generated by the measuring conductor would simply cancel that of the first conductor. The voltage difference generated by the two materials can then be measured and related to the corresponding temperature gradient. It is thus clear that, based on Seebeck's principle; thermocouples can only measure temperature differences and need a known reference temperature to yield the absolute readings.

Circuit Diagram:

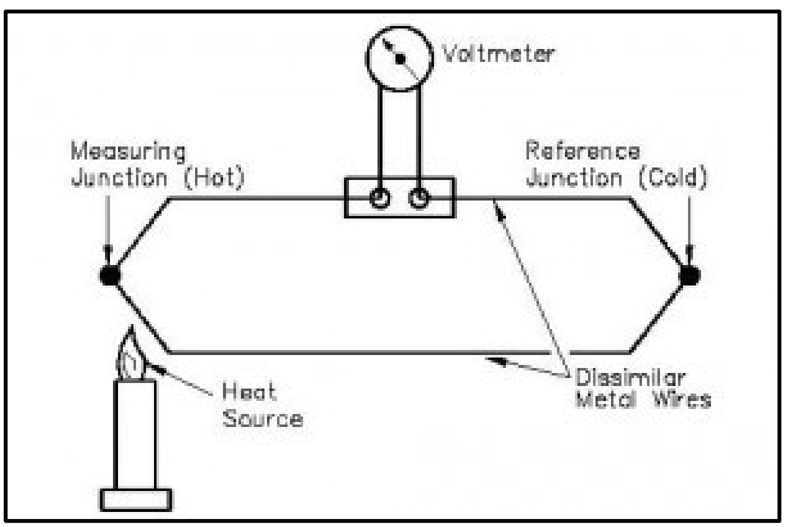


Figure 7: Circuit diagram of seebeck Effect.

Procedure

1. Select the type of thermocouple from the 'Choose Thermo Couple Type' combo box.
2. Adjust the temperature slider to a specific temperature.
3. Note down the emf generated using the voltmeter.
4. Plot temperature versus emf graph and analyze to get some conclusion.

Observation:

Sr.No	**Temperature (°C)**	**EMF (Volts)**	
		J-Type	K-Type
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Calculations:

Result:

Viva Questions:

1. What is seebeck effect?
2. What is Peltier effect?
3. What are the units of Planck's constant?

Answers:

Name: -

Branch / Div: - Roll No: -

Experiment No: 06

TITLE: Simulation of Carbon nano-structure

Date of Performance:

Date of Completion:

Rubrics for Assessment of Experiment
Performance Indicators for assessing Lab Outcomes

Performance Indicator	Exceed Expectations (EE)	Meet Expectations (ME)	Below Expectations (BE)	Marks Obtained
Performance (03 marks)	*The entire experiment was performed within the assigned time with full attention. (03)*	*The entire experiment was executed on the deadline with less attention (02)*	*The entire experiment was performed beyond the assigned time. (01)*	
Readings, Calculations & Graphs (03 marks)	*All the readings taken are in the range. All figures & Graphs are correctly drawn & Calculations are done accurately (03)*	*All the readings taken are not in the range. All figures &, Graphs are correctly drawn but some important features are missing & Calculations are done incorrectly (02)*	*All the readings are beyond range. All figures & Graphs are poorly drawn & Calculations are done incorrectly (01)*	
Understanding (02 marks)	*Complete understanding of the aim of the experiment and the basic concepts (02)*	*Incomplete understanding of the aim of the experiment and the basic concepts (01)*	*Very less understanding of the aim of the experiment and the basic concepts (0.5)*	
Timely submission (02 marks)	*Very neat and complete write-ups submitted on the assigned day. (02)*	*Write-ups submitted late by 2-4 day (01)*	*Write-ups submitted late by 4-6 day (0.5)*	
Total Marks				

Experiment No. 06

Simulation of Carbon-nanostructure

Aim: To understand and draw carbon-60 structure (Fullerene).

Apparatus: Avogadro Software

Procedure:

1. Download the Avogadro software in computer lab.
2. Understand the drawing tools of Avogadro software.
3. Draw the C-60 structure with following steps.
4. Draw 5 carbon atoms and join them with single bond and use UFF 4 to optimize and convert it into regular pentagon.

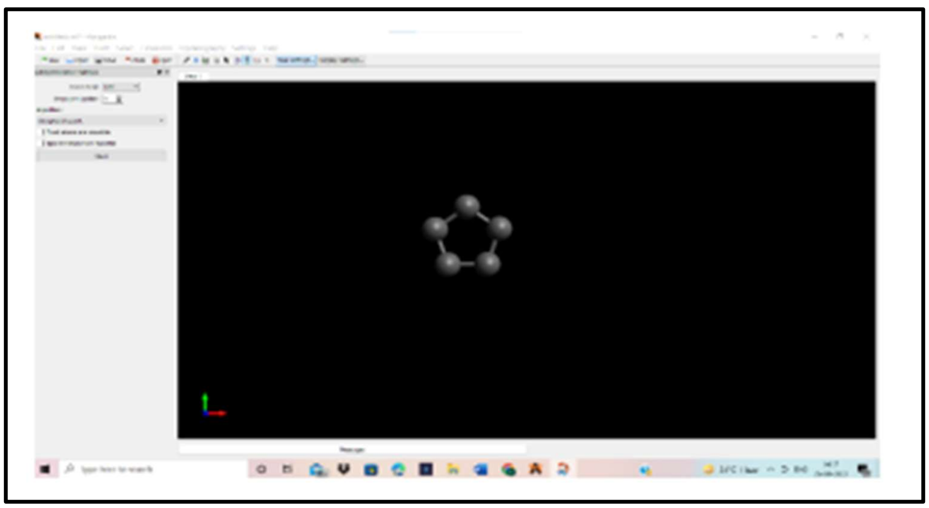


Figure 9: Carbon Structure

5. Do not forget to stop optimization whenever used.
6. Draw 5 hexagons with each side of pentagon and optimize.
7. In the valley formed by each hexagon, draw 5 pentagons by adding 2 carbon atoms each time and optimize.
8. In the valley formed by each pentagon, draw 5 hexagons by adding 2 carbon atoms each time and optimize.
9. In the valley formed by each hexagon, again draw 5 hexagons by adding 2 carbon atoms each time and **but do not optimize**.
10. In the valley formed by each hexagon, now draw 5 pentagons by adding 1 carbon atoms each time.
11. Now optimize and wait for the structure to take shape.

12. Draw five carbon atoms surrounding the central pentagon and join them to complete the pentagon.
13. Join these five carbon atoms to the five topmost carbon atoms.
14. Join these five carbon atoms to the five topmost carbon atoms.
15. This is the C60 Fullerene structure.

Diagrams of the optimized carbon Nano-structures:

Result:

Viva Questions:

1. What are nanomaterials? Give any three properties.
2. Give any two methods of synthesis for nanomaterials.
3. Write down any two applications of nanomaterials.

Answers:

Name: -
Branch / Div: - Roll No: -
Experiment No: 07
TITLE: Measurement of Hall Voltage
Date of Performance:
Date of Completion:

Rubrics for Assessment of Experiment
Performance Indicators for assessing Lab Outcomes

Performance Indicator	Exceed Expectations (EE)	Meet Expectations (ME)	Below Expectations (BE)	Marks Obtained
Performance (03 marks)	*The entire experiment was performed within the assigned time with full attention. (03)*	*The entire experiment was executed on the deadline with less attention (02)*	*The entire experiment was performed beyond the assigned time. (01)*	
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Understanding (02 marks)	*Complete understanding of the aim of the experiment and the basic concepts (02)*	*Incomplete understanding of the aim of the experiment and the basic concepts (01)*	*Very less understanding of the aim of the experiment and the basic concepts (0.5)*	
Timely submission (02 marks)	*Very neat and complete write-ups submitted on the assigned day. (02)*	*Write-ups submitted late by 2-4 day (01)*	*Write-ups submitted late by 4-6 day (0.5)*	
Total Marks				

Experiment No.: 07

MEASUREMENT OF HALL VOLTAGE

Aim: – To measure the Hall voltage developed across a semiconductor sample and determine the Hall coefficient.

Apparatus: – Hall effect setup with semiconductor sample, Hall probe *(sample – Indium Arsenide)*, Electromagnet with power supply, Gauss meter (to measure magnetic field), Constant current source, Digital voltmeter, Connecting wires.

Theory:- When a current carrying sample (metal or semiconductor) is kept in a homogeneous external magnetic field, then a potential difference called Hall voltage gets developed between the opposite faces. The direction of this Hall field is perpendicular to both applied magnetic field & the current through sample. This effect occurs because, when the charge carriers move through sample for current conduction, they experience force due to magnetic field & they get deflected in direction perpendicular to both applied field & direction of motion of carriers.

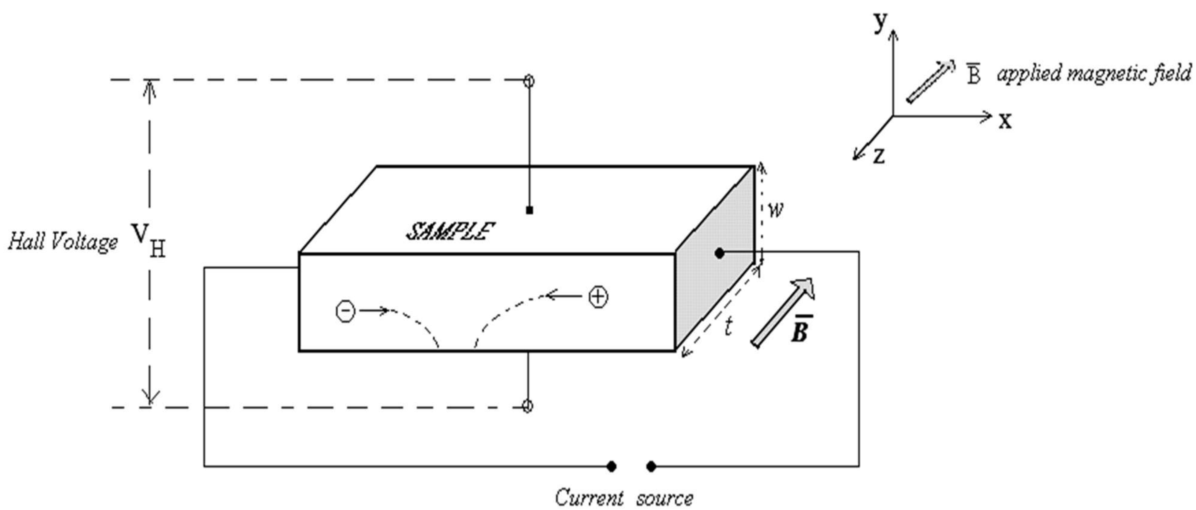


Figure 10: Diagram illustrating the occurrence of Hall effect.

The drifting carriers start accumulating near the one surface of sample as shown in following diagram & this makes an electric potential getting developed between that surface & the opposite one. Thus, the new electric field arises in the sample called Hall electric field which now exerts force on the carriers which happens to be in the opposite direction to that of magnetic field force. Thus, deflection in carriers path, accumulation of charges at surface continues till the magnetic field force dominates over hall field force. Gradually increasing charge accumulation makes Hall field stronger & stronger until it perfectly balances the force due to magnetic field. This is the saturation state & path of charge carriers do not deflect further. The voltage developed between the opposite faces of sample due to saturated accumulation of charges is then called Hall voltage.

At saturation stage we get for hall field intensity, $E_H = \dfrac{BJ}{ne} = \dfrac{1}{ne}BJ = R_H\, BJ$

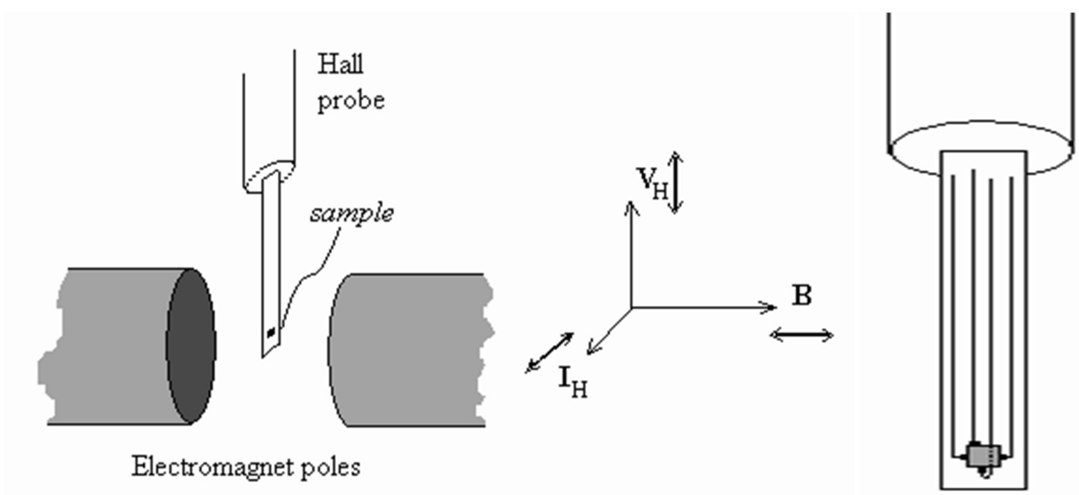
Here term $R_H = \dfrac{1}{ne}$ is termed as Hall coefficient.

Thus, we get expression for Hall coefficient as $R_H = \dfrac{E_H}{BJ}$

But experimentally, $E_H = \dfrac{V_H}{w}$ & $J = \dfrac{I}{w.t}$

Hence $R_H = \dfrac{V_H}{B}\dfrac{t}{I}$ with 't' is the dimension of sample chip along direction of $\overline{B}$

Diagram:



Electrical connections for sample in the probe

Figure 11: Experimental setup of Hall Effect.

Formula: Hall Coefficient of a sample in Hall Effect is given by $R_H = \dfrac{V_H\ t}{B.I}$

Where V_H – Hall voltage measured across the sample

B – Applied magnetic field induction

I – Current flowing through sample

t – Thickness of sample along the direction of applied magnetic field

Procedure:

6. Maintain distance between the electromagnet pole pieces to a desired value (say 10 mm) using the spacers given with the kit. Set the electromagnet current to some desired value, say 300 mA, note down the current value in observations & write the corresponding magnetic flux from calibration chart. Do not disturb this throughout the experiment.
7. Set the Probe current at +/- 100 mA. Adjust ZERO control so that PROBE OUTPUT meter reads zero. Do not disturb this throughout the experiment.
8. Insert carefully the hall probe with fitting cap on it through the hole provided for fitting purpose. Hold it so that the probe faces are parallel to pole faces. Also, make sure that probe tip should lie at the centre of the poles. Do not disturb this arrangement throughout the experiment.
9. Now start applying various values of probe current & note down corresponding values of PROBE OUTPUT i.e. Hall voltage.
10. Use '+' as well as '–'values of probe currents.

Circuit Diagram:-

Observations:

- Distance between pole-pieces of electromagnet = _______
- Electromagnet current =____________
- Magnetic field present in the gap between poles, **B =__________**
- Thickness of sample along the field direction, **t = 0.14 mm**

Sr. No	Sample Current 'I' *in mA*	Hall Voltage 'V_H' *in mV*
1.	-60	
2.	-50	
3.	-40	
4.	-30	
5.	-20	
6.	-10	
7.	0	
8.	10	
9.	20	
10.	30	
11.	40	
12.	50	
13.	60	

Graph:

Plot a graph of Hall voltage 'V_H' against sample current 'I'.

Calculations:

The slope of graph is

$$slope = \frac{V_H}{I} = \_\_\_\_\_\_\_\_\_\_$$

According to formula, Hall coefficient is given as,

$$R_H = \frac{V_H}{I}\frac{t}{B} = slope \cdot \frac{t}{B} = \text{-----------------------}$$

R_H = ____________________ m^3/Coulomb

Results:

For the given Hall probe sample (which is "Indium Arsenide"),

- Hall coefficient is R_H = ____________________

Viva Questions:

1. What is the Hall effect?
2. How is Hall voltage generated?
3. What does the sign of Hall coefficient indicate?
4. Why is the Hall effect more prominent in semiconductors than in metals?
5. Mention any two applications of the Hall effect.

Answers:

Name: -

Branch / Div: - Roll No: -

Experiment No: 08

TITLE: Ultrasonic distance measurement

Date of Performance:

Date of Completion:

Rubrics for Assessment of Experiment
Performance Indicators for assessing Lab Outcomes

Performance Indicator	Exceed Expectations (EE)	Meet Expectations (ME)	Below Expectations (BE)	Marks Obtained
Performance (03 marks)	*The entire experiment was performed within the assigned time with full attention. (03)*	*The entire experiment was executed on the deadline with less attention (02)*	*The entire experiment was performed beyond the assigned time. (01)*	
Readings, Calculations & Graphs (03 marks)	*All the readings taken are in the range. All figures & Graphs are correctly drawn & Calculations are done accurately (03)*	*All the readings taken are not in the range. All figures &, Graphs are correctly drawn but some important features are missing & Calculations are done incorrectly (02)*	*All the readings are beyond range. All figures & Graphs are poorly drawn & Calculations are done incorrectly (01)*	
Understanding (02 marks)	*Complete understanding of the aim of the experiment and the basic concepts (02)*	*Incomplete understanding of the aim of the experiment and the basic concepts (01)*	*Very less understanding of the aim of the experiment and the basic concepts (0.5)*	
Timely submission (02 marks)	*Very neat and complete write-ups submitted on the assigned day. (02)*	*Write-ups submitted late by 2-4 day (01)*	*Write-ups submitted late by 4-6 day (0.5)*	
Total Marks				

Experiment No.: 08
ULTRASONIC DISTANCE MEASUREMENT

Aim: – To use ultrasonic distance measuring unit for measuring distances.

Apparatus: – Ultrasonic Distance Measurer (EUROLAB DIST2)

Theory: – Ultrasonic waves travel as a highly directional beam & hence can be used for distance measuring purpose through echo-sounding technique.

One ultrasonic pulse is sent by the instrument & received back after getting rebound at a surface. The time difference between sending instant & receiving instant (echo time) is measured. By knowing velocity of ultrasonic waves in the medium (air), the distance of surface or obstacle from the instrument can be calculated as

$$\text{Distance} = \frac{\text{velocity of ultrasonic waves} \times \text{echo time}}{2}$$

In an ultrasonic distance measurer, the whole process is done automatically using electronic components & the display of measurer shows directly the distance value.

Diagram:-

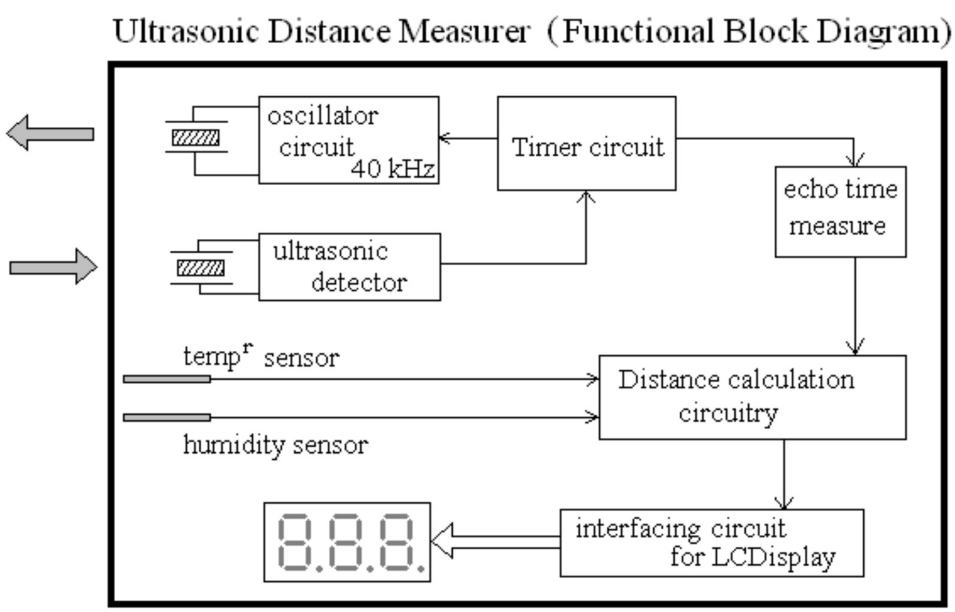


Figure 11: Ultrasonic distance meter block diagram

Observations:

Measurement range available with given instrument is **0.91m to 15m**

Measurement of Area & Volume of a Room: ____________________

Sr No.	Length	Width	Height
1			
2			
3			
4			
5			
6			
7			
Average			

Results:

Carpet Area of the room = _________

Volume of the room space = ____________

Remarks: Ultrasonic waves can be used for distance measurement. The Ultrasonic Distance Measurer that we used is ideal for use in building construction & related businesses

Viva Questions:

1. How is ultrasonic distance measured?
2. What is the maximum distance the ultrasonic sensor can detect?
3. What is the normal frequency range used for ultrasonic level measurements?
4. What logic is used in ultrasonic distance of object?

Answers:

Name: -

Branch / Div: - Roll No: -

Experiment No: 09

TITLE: Calibration of PT100

Date of Performance:

Date of Completion:

Rubrics for Assessment of Experiment
Performance Indicators for assessing Lab Outcomes

Performance Indicator	Exceed Expectations (EE)	Meet Expectations (ME)	Below Expectations (BE)	Marks Obtained
Performance (03 marks)	*The entire experiment was performed within the assigned time with full attention. (03)*	*The entire experiment was executed on the deadline with less attention (02)*	*The entire experiment was performed beyond the assigned time. (01)*	
Readings, Calculations & Graphs (03 marks)	*All the readings taken are in the range. All figures & Graphs are correctly drawn & Calculations are done accurately (03)*	*All the readings taken are not in the range. All figures &, Graphs are correctly drawn but some important features are missing & Calculations are done incorrectly (02)*	*All the readings are beyond range. All figures & Graphs are poorly drawn & Calculations are done incorrectly (01)*	
Understanding (02 marks)	*Complete understanding of the aim of the experiment and the basic concepts (02)*	*Incomplete understanding of the aim of the experiment and the basic concepts (01)*	*Very less understanding of the aim of the experiment and the basic concepts (0.5)*	
Timely submission (02 marks)	*Very neat and complete write-ups submitted on the assigned day. (02)*	*Write-ups submitted late by 2-4 day (01)*	*Write-ups submitted late by 4-6 day (0.5)*	
Total Marks				

Experiment No.:09

CLLIBRATION OF PT100

Aim: – To calibrate a PT100 temperature sensor and establish the relationship between temperature and resistance.

Apparatus: – PT100 sensor, Standard thermometer, Temperature bath, Digital multimeter, Connecting wires, Beaker, Ice cubes, Heater / Burner.

Theory: – PT100 is a platinum resistance temperature detector (RTD) where "100" indicates that the sensor has a resistance of 100 ohms at 0°C. As the temperature increases, the resistance of the PT100 also increases linearly over a certain temperature range. Calibration involves measuring the resistance at known temperatures and comparing it to standard reference values.

The relationship between resistance and temperature for a PT100 sensor is approximately linear within a limited temperature range.

Diagram:-

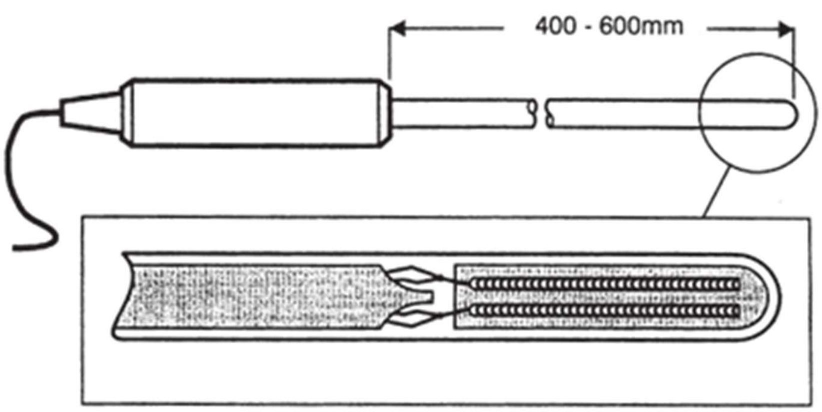


Figure 12: Standard Platinum Resistance Thermometer

Figure 13: High Precision Digital Thermometer

Formula:

Temperature (T) vs Resistance (R) relation:

$R(T) = R_0 (1 + \alpha T)$

where,

- $R(T)$ = Resistance at temperature T
- R_0 = Resistance at 0°C (typically 100 Ω)
- α = Temperature coefficient of resistance (approximately 0.00385 /°C for platinum)

Procedure:

1. Connect the PT100 sensor to the resistance measuring instrument.
2. Place the PT100 sensor and the standard thermometer into a temperature bath.
3. Record the resistance of PT100 and the corresponding temperature reading from the thermometer.
4. Gradually vary the temperature (by adding ice or using a heater) and repeat the measurements at different temperatures.
5. Take at least 6-8 readings across the temperature range.
6. Plot a graph of resistance (R) versus temperature (T).
7. Determine the temperature coefficient α from the slope of the graph.

Observations:

Sr No.	Temperature T (°C)	Resistance R (Ω)
1		
2		
3		
4		
5		
6		
7		

Graph:

Plot Resistance (Y-axis) vs Temperature (X-axis)

Calculations:

- Calculate α from slope
- Compare experimental and theoretical values

Results:

The experimental value of temperature coefficient α is found to be __________ 1/°C.

Viva Questions:

1. Why is platinum used in PT100 sensors?
2. What is the significance of calibrating a temperature sensor?
3. How does the resistance of PT100 vary with temperature?

Answers:

Name: -

Branch / Div: - Roll No: -

Experiment No: 10

TITLE: Characteristics of LDR.

Date of Performance:

Date of Completion:

Rubrics for Assessment of Experiment
Performance Indicators for assessing Lab Outcomes

Performance Indicator	Exceed Expectations (EE)	Meet Expectations (ME)	Below Expectations (BE)	Marks Obtained
Performance (03 marks)	*The entire experiment was performed within the assigned time with full attention. (03)*	*The entire experiment was executed on the deadline with less attention (02)*	*The entire experiment was performed beyond the assigned time. (01)*	
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Understanding (02 marks)	*Complete understanding of the aim of the experiment and the basic concepts (02)*	*Incomplete understanding of the aim of the experiment and the basic concepts (01)*	*Very less understanding of the aim of the experiment and the basic concepts (0.5)*	
Timely submission (02 marks)	*Very neat and complete write-ups submitted on the assigned day. (02)*	*Write-ups submitted late by 2-4 day (01)*	*Write-ups submitted late by 4-6 day (0.5)*	
Total Marks				

Experiment No.: 10

CHARACHERSTICS OF LDR

Aim: – To study the characteristics of a Light Dependent Resistor (LDR) and observe the variation in resistance with changing light intensity.

Apparatus: – LDR (Light Dependent Resistor), Lux meter or controlled light source (e.g., lamp), Voltmeter, Ammeter, Variable resistor (potentiometer), Power supply (DC), Connecting wires, Breadboard or circuit board, Meter Scale.

Theory: – Light Dependent Resistors, also known as photoresistors or photoconductive cells works on the principle of Photoconductivity. Photoresistors are made from semiconductor materials whose resistance changes when illuminated with light energy. Such materials (also known as photo-conductors) are Cadmium Sulphide (CdS), Cadmium Selenium (CdSe) and Lead Sulphide (PbS). The figure below shows a commonly used CdS cell.

When these materials are exposed to light, the covalent bonds are broken. This produces charge carriers. The amount of illumination on the surface of the material determines the number of electron hole pairs generated in the material. This in turn determines the resistance of the Photoconductive cells. The greater the amount of light falling on the surface (called surface illumination), the greater will be the number of electron-hole pairs generated and therefore lower will be the value of resistance of the material. The lower the amount of light falling on the surface, the higher the value of resistance of the material. Thus, the resistance of the semiconductor varies inversely with the intensity of light. When the device is kept in darkness, its resistance is called Dark Resistance. When light falls on it, its resistance decreases up to several kilo ohms or even hundreds of ohms, depending on the intensity of light falling on it. The construction of the LDR consists of light sensitive material deposited on an insulating substrate like a ceramic. To get the desired resistance and power rating, the metal is deposited in the pattern of a zigzag. This pattern separates the metal deposited areas into two regions and on both sides of the pattern the Ohmic contact is prepared.

Diagram:-

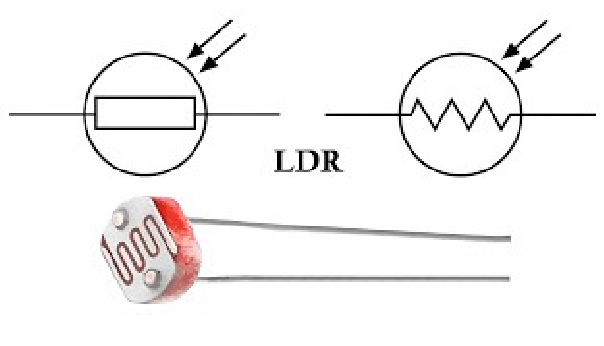

Figure 14: Symbol of LDR

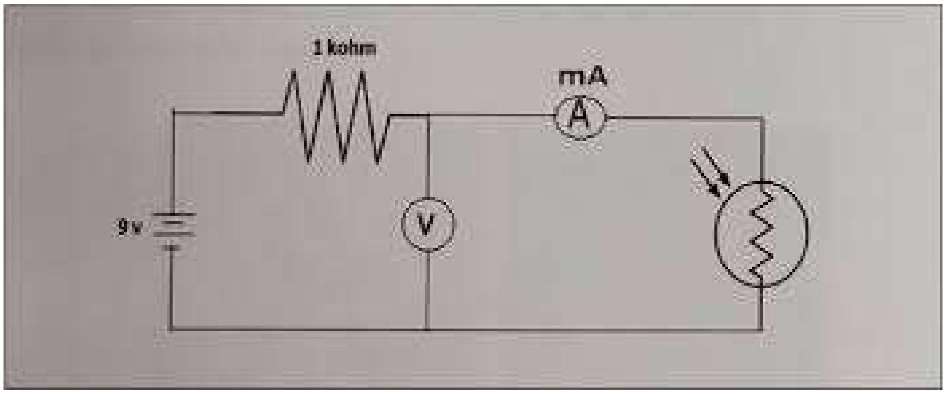

Figure 15: Circuit diagram

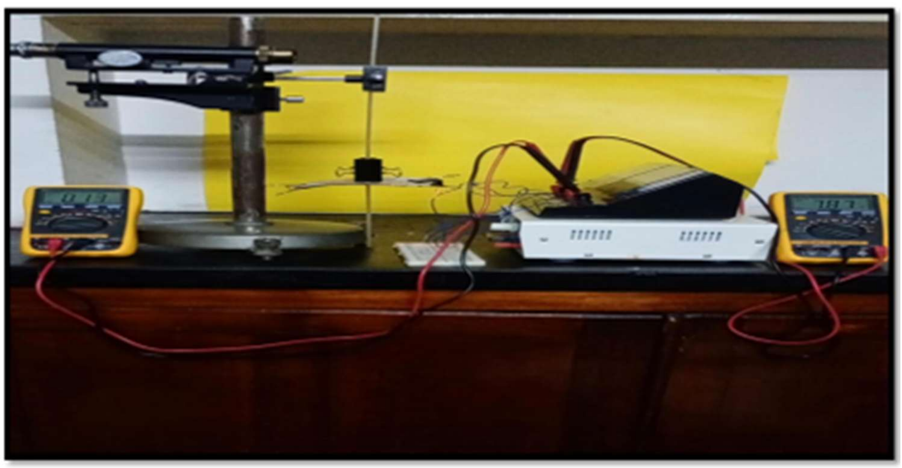

Figure 16: Experimental Arrangement

Formula:

Ohm's Law:

Where,

- = Resistance of the LDR (in ohms)
- = Voltage across the LDR (in volts)
- = Current through the LDR (in amperes)

Procedure:

1. Connect the LDR in series with a power supply and a resistor (as per the circuit diagram).
2. Place a light source at a known distance from the LDR.
3. Switch on the power supply.
4. Measure the voltage across and current through the LDR using voltmeter and ammeter respectively.
5. Vary the light intensity (by changing the distance or brightness of the lamp) and record the new voltage and current values.
6. Repeat the experiment for different light intensities.
7. Calculate the resistance of the LDR for each light intensity using Ohm's law.
8. Plot a graph of resistance vs light intensity.

Observations:

Sr No.	Distance d (cm)	Voltage V (Volts)	Current I (mA)
1			
2			
3			
4			
5			
6			
7			
8			
9			

Graph:

Plot current I (Y-axis) vs voltage V (X-axis)

Calculations:

- Calculate resistance for each reading using
- Observe the trend

Results:

As the light intensity increased, the resistance of the LDR _____________, confirming its ________________ relationship.

Viva Questions:

1. What is an LDR and how does it work?
2. What factors affect the resistance of an LDR?
3. Mention two applications of LDRs in real-world systems.

Answers:

