



## LABORATORY MANUAL

**B.Tech. Semester- I/ II**

**PHYSICS LAB**

**Subject code: BSP-103P**

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**DEPARTMENT OF APPLIED SCIENCE & HUMANITIES  
DRONACHARYA COLLEGE OF ENGINEERING  
KHENTAWAS, FARRUKH NAGAR, GURUGRAM (HARYANA)**

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### Vision and Mission of the Institute

**Vision:**

“ To impart Quality Education, to give an enviable growth to seekers of learning, to groom them as World Class Engineers and managers competent to match the expending expectations of the Corporate World has been ever enlarging vision extending to new horizons of Dronacharya College of Engineering.”

**Mission:**

**M1.** To prepare students for full and ethical participation in a diverse society and encourage lifelong learning by following the principle of ‘Shiksha evam Sahayata’ i.e. Education & Help.

**M2.** To impart high-quality education, knowledge and technology through rigorous academic programs, cutting-edge research, & Industry collaborations, with a focus on producing engineers & managers who are socially responsible, globally aware, & equipped to address complex challenges.

**M3.** Educate students in the best practices of the field as well as integrate the latest research into the academics.

**M4.** Provide quality learning experiences through effective classroom practices, innovative teaching practices and opportunities for meaningful interactions between students and faculty.

**M5.** To devise and implement program of education in technology that are relevant to the changing needs of society, in terms of breadth of diversity and depth of specialization.

### Vision and Mission of the Department

**Vision:**

To lay a strong foundation for the first year students of the engineering discipline in the area of Applied Sciences and Humanities with a view to make them capable of innovating and inventing engineering solutions and also develop students as capable and responsible citizens of our nation.

**Mission:**

- To build strong fundamental knowledge and ability for application in students and make them capable to apply knowledge of mathematics and science to the solution of complex engineering problems.
- To impart knowledge, leading to understanding between engineering and other core areas of Applied Sciences and Humanities.
- To provide students the basic tools of analysis, as well as the knowledge of the principles on which engineering is based.
- To strive to inculcate the scientific temper and the spirit of enquiry in the students.
- To make students achieve a superior level in communication and presentation skills.
- To foster values and ethics and make students responsible citizens of India.
- To pursue inter-disciplinary research for the larger good of the society.

### Programme Educational Objectives (PEOs)

- PEO1:** To provide students with a sound knowledge of mathematical, scientific and engineering fundamentals required to solve real world problems.
- PEO2:** To develop research oriented analytical ability among students and to prepare them for making technical contribution to the society.
- PEO3:** To prepare students with effective communication skills, professional ethics and managerial skills.
- PEO4:** To prepare students with the ability to upgrade their skills and knowledge for life-long learning.
- PEO5:** At the end of the program, the students will develop a strong analytical skill and will be able to study critically a physics problem, solve the problem using different tools and present the result/conclusion.
- PEO6:** Demonstrate conceptual understanding of fundamental physics principles. Communicate physics reasoning in oral and in written form. Solve physics problems using qualitative and quantitative reasoning including sophisticated mathematical techniques.
- PEO7:** Practice in professions requiring a fundamental understanding of the principles of physics and engineering.
- PEO8:** Maintain professional proficiency in rapidly-advancing scientific and technical areas.
- PEO9:** Pursue advanced degrees in physics, engineering, and other professional fields.

### Programme Outcomes (POs)

- PO1:** Be able to apply knowledge of mathematics, science, and engineering.
- PO2:** Be able to design and conduct experiments, as well as to analyze and interpret data.
- PO3:** Be able to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
- PO4:** Be able to function on multidisciplinary teams.
- PO5:** Be able to identify, formulate, and solve engineering problems.
- PO6:** Be able to demonstrate an understanding of professional and ethical responsibility.
- PO7:** Be able to communicate effectively in oral form.
- PO8:** Be able to communicate effectively in written form.
- PO9:** Have the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.
- PO10:** Recognize the need for and have an ability to engage in life-long learning.
- PO11:** Be able to demonstrate knowledge of contemporary issues.
- PO12:** Be able to use the techniques, skills, and modern engineering tools necessary for engineering practice

## **Program Specific Outcomes (PSOs)**

**PSO-1:** Students would be able to explain the basic concepts of Quantum Mechanics and the band theory of solids.

**PSO-2:** To enable students to learn and to apply the basic concepts of properties of matter in day to day life.

**PSO-3:** To learn the types of Semiconductors and the role of carrier concentrations in conductivity. Understand the behavior of materials at low temperatures and the applications of Super conductivity.

**PSO-4:** Understand the use of Semiconductor Physics in Engineering Science, and apply the concepts to evaluate capacitance, resistance in various semiconductor device systems.

**PSO-5:** The student will get a basic understanding of Nanotechnology. The course will give idea of synthesis, characterization of Nano materials and electrical & optical properties, application of Nano systems.

# University Syllabus

**Note: At least 8 experiments are to be performed by the students.**

**List of Subject related Experiments:**

1. To find out wavelength of monochromatic light using Newton's ring experiment.
2. To find out wavelength of monochromatic light using Diffraction grating.
3. To find out wavelength of monochromatic light using Fresnel's bi-prism
4. To study interference phenomena using Michelson's Interferometer and to find out wavelength of monochromatic light.
5. To study Hall effect in semiconductors and measure the Hall coefficient.
6. To find frequency of AC mains using sonometer.
7. To study the magnetic properties of materials using B-H curve.
8. To study the Curies temperature of materials using Dielectric set up.
9. To verify the inverse square law with the help of a photovoltaic cell.
10. To determine Planks constant using photocell.
11. To study the characteristics of Solar cell and find out the fill factor.
12. To find temperature co-efficient of platinum using Callender Griffith bridge.
13. To study the forward and reverse characteristics of P-N junction diode



## Physics Lab (BSP-103P)

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### Course Outcomes (COs)

Upon successful completion of the course, the students will be able to:

C103.1: Develop skills to impart practical knowledge in real time solution.

C103.2: Understand principle, concept, working and application of new technology and comparison of results with theoretical calculations.

C103.3: Design new instruments with practical knowledge.

C103.4: Gain knowledge of new concept in the solution of practical oriented problems and to understand more deep knowledge about the solution to theoretical problems.

C103.5: Understand measurement technology, usage of new instruments and real time applications in engineering studies.

### CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
C103.1		2			2			2	2	2	2	2
C103.2			2		2			2	2	2	2	2
C103.3				2	2			2	2	2	2	2
C103.4				2	2			2	2	2	2	2
C103.5				2	2			2	2	2	2	2
<b>C103</b>		<b>2</b>	<b>2</b>	<b>2</b>	<b>2</b>			<b>2</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>2</b>

### CO-PSO Mapping

	PSO1	PSO2	PSO3
C103.1	2	2	
C103.2		2	
C103.3		2	
C103.4		2	
C103.5		2	
<b>C103</b>	<b>2</b>	<b>2</b>	

### **Course Overview**

Engineering Physics Lab provides an experimental foundation for the theoretical concepts introduced in the lectures. It also discusses how to make careful experimental observations and how to think about and draw conclusions from such data. The students understand the role of direct observation in physics and to distinguish between inferences based on theory and the outcomes of experiments. It introduces the concepts and techniques which have a wide application in experimental science but have not been introduced in the standard courses. Finally the students are able to write a technical report which communicates scientific information in a clear and concise manner.

## Physics Lab (BSP-103P)

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### List of Experiments mapped with COs

<i>S.No.</i>	<i>List of Experiments</i>	<i>Course Outcome</i>	<i>Page No.</i>
1	To find out wavelength of monochromatic light using Newton's ring experiment.	C103.1	1-9
2	To find out wavelength of monochromatic light using Diffraction grating.	C103.1	10-14
3	To study Hall effect in semiconductors and measure the Hall coefficient.	C103.2	15-18
4	To find frequency of AC mains using sonometer.	C103.4	19-23
5	To determine the hysteresis loss by C.R.O.	C103.4	24-28
6	To study the characteristics of Solar cell and find out the fill factor.	C103.3	29-33
7	To determine Planks constant using photocell.	C103.5	34-39
8	To study the characteristics of Solar cell and find out the fill factor.	C103.5	40-46
9	To find temperature co-efficient of platinum using Callender Griffith bridge.	C103.5	47-51
10	To study the forward and reverse characteristics of P-N junction diode	C103.5	52-57

### DOs and DON'Ts

#### PHYSICS LABORATORY

- 1.) Do not consume any food or drink in the laboratory. Any food or drink brought to the lab must remain in the students carrying bag until they leave.
- 2.) Do wear appropriate clothing to laboratory. This includes shoes that are not open toed (No sandals, slippers, etc.). Please wear clothing to lab that you don't care if it gets dirty. We don't have a lot of chemicals but you will have to kneel on the floor to make measurements and some of the equipment can have greasy rotation points.
- 3.) Do place all sensitive electronic equipment safely on your table or within your bag under your table so that expensive damage can be avoided.
- 4.) Do not modify or damage the laboratory equipment in any way unless the modification is directed by the instructor. This does not include the changing of a lab setup as prescribed by the procedures in the carrying out of measurements.
- s) Do use care when loosening and tighten screws and bolts. Treat the equipment as if it were your own.
- 6.) Do not force any of the equipment. If an excessive amount of force is necessary then tell your instructor.
- 7.) In case the fire alarm sounds, please do exit the building by the nearest safe exit. If the fire is in the room leave everything behind. If the fire is not in the room and immediate danger is not apparent, then quickly and quietly pack your bag and exit the room or just leave the stuff behind. The instructor will lock the doors on the way out to ensure security.
- 8.) In the case of any other emergency, do follow the instructions of the laboratory instructor and all safety personal that may have responded to the scene.
- 9.) Do handle all laboratory apparatus according to their instructions.
- 10.) After using the apparatus, do clean them properly and placed them back to their proper places

### General Safety Precautions

#### Precautions (In case of Injury or Electric Shock)

1. To break the victim with live electric source, use an insulator such as fire wood or plastic to break the contact. Do not touch the victim with bare hands to avoid the risk of electrifying yourself.
2. Unplug the risk of faulty equipment. If main circuit breaker is accessible, turn the circuit off.
3. If the victim is unconscious, start resuscitation immediately, use your hands to press the chest in and out to continue breathing function. Use mouth-to-mouth resuscitation if necessary.
4. Immediately call medical emergency and security. Remember! Time is critical; be best.

#### Precautions (In case of Fire)

1. Turn the equipment off. If power switch is not immediately accessible, take plug off.
2. If fire continues, try to curb the fire, if possible, by using the fire extinguisher or by covering it with a heavy cloth if possible isolate the burning equipment from the other surrounding equipment.
3. Sound the fire alarm by activating the nearest alarm switch located in the hallway.
4. Call security and emergency department immediately:

**Emergency** : **Reception**

**Security** : **Main Gate**

### Guidelines to students for report preparation

All students are required to maintain a record of the experiments conducted by them. Guidelines for its preparation are as follows:-

- 1) All files must contain a title page followed by an index page. *The files will not be signed by the faculty without an entry in the index page.*
- 2) Student's Name, Roll number and date of conduction of experiment must be written on all pages.
- 3) For each experiment, the record must contain the following
  - (i) Aim/Objective of the experiment
  - (ii) Pre-experiment work (as given by the faculty)
  - (iii) Lab assignment questions and their solutions
  - (iv) Test Cases (if applicable to the course)
  - (v) Results/ output

**Note:**

1. Students must bring their lab record along with them whenever they come for the lab.
2. Students must ensure that their lab record is regularly evaluated.

# **LAB EXPERIMENTS**

# Physics Lab (BSP-103P)

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## LAB EXPERIMENT 1

### Newton's rings

- Aim :** 1. To determine the wavelength of sodium light by Newton's ring.  
2. Plot a graph between 'n' and 'D<sup>2</sup>' in the case of Newton's rings and hence find the radius of curvature of the surface of the lens

### Apparatus Required :

A plano-convex lens of large radius of curvature, optical arrangement for Newton's rings, plane glass plate, sodium lamp and travelling microscope.

### Formula used :

The wavelength  $\lambda$  of light is given by the formula:

$$\lambda = \frac{D_{n+p}^2 - D_n^2}{4pR}$$

Where,  $D_{n+p}$  = diameter of (n+p)th ring,  $D_n$  = diameter of nth ring,  
p = an integer number (of the rings)  
R = radius of curvature of the curved face of the plano-convex lens.

### Description of apparatus :

The optical arrangement for Newton's ring is shown in fig. (1). Light from a monochromatic source (sodium lamp) is allowed to fall on the convex lens through a broad slit which renders it into a nearly parallel beam. Now it falls on a glass plate inclined at an angle  $45^\circ$  to the vertical, thus the parallel beam is reflected from the lower surface. Due to the air film formed by a glass plate and a plano convex lens of large radius of curvature, interference fringes are formed which are observed directly through a travelling microscope. The rings are concentric circles.



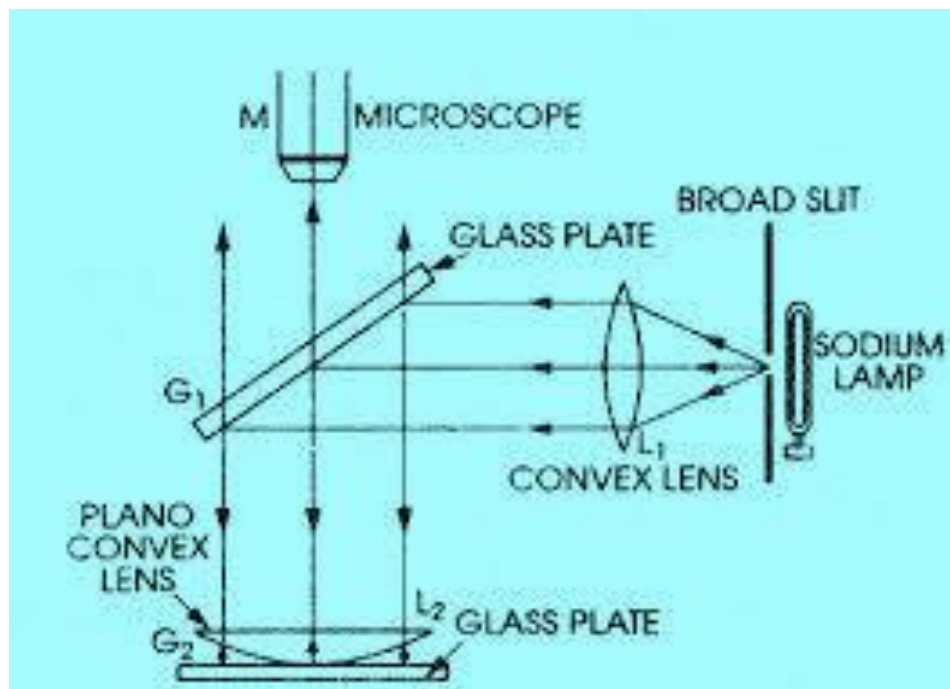


Figure 1

### **Theory:**

A plano-convex lens is placed with its convex surface on the optically plane glass plate so as to enclose a thin film of air of varying thickness between the lens and the plate. Light from an extended monochromatic source (i.e. sodium lamp) of light is converted into a parallel beam of light by using a convex lens ' $L_1$ ' of short focal length and made to fall on an optically plane glass plate inclined at an angle of  $45^\circ$  to the vertical, where it gets reflected on to the plano-convex lens ' $L_2$ ' as shown in Fig.1 Interference takes place between the rays of light reflected from the upper and the lower surfaces of the wedge shaped air film enclosed between lens  $L_2$  and glass plate  $P$  and circular interference fringes (alternate dark & bright) called Newton's rings are produced as shown in Fig.2

The center will be dark because at the center, lens is in contact with the glass plate and thickness of air film at the center is zero. By Stoke's law, a phase change of (or path difference of Fig.2) takes place due to the reflection at the lower surface of the film (Fig.3) as the ray of light passes from rarer from denser medium. As we proceed outwards from the center, the thickness of the film gradually increases being the same all along the circle with the center at the point of contact.

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Thus the fringes produced are concentric circles and localized in the air film.

The fringes can be viewed by means of a low power travelling microscope 'M' as shown in Fig.1. The fringes are circular due to the fact that air film is symmetrical about the point of contact. The locus of all the points at same thickness is a circle i.e. all the points where the air film has a given thickness lie on a circle whose center is at 'O'.

Let 'R' be the radius of curvature of the surface of plano-convex lens in contact with the glass plate P.

**$D_n$  = diameter of the n dark ring**

**$\lambda$  = Wavelength of monochromatic source of light used**

then,  $D_n^2 = 4nR\lambda$

It may be pointed out that surfaces of the lens and the plate may not be clean and the lens may not be perfect contact with the glass plate at the center. The center will not be dark. To eliminate the error due to this problem, the diameter of any two dark rings say,  $n^{\text{th}}$  and  $(n+m)^{\text{th}}$  may be determined.

Therefore,

$$D_n^2 = 4nR\lambda \dots \dots \dots (1)$$

$$D_{n+m}^2 = 4(n+m)R\lambda \dots \dots \dots (2)$$

From equations (1) and (2), we get

$$\lambda = (D_n^2 - D_{n+m}^2) / 4(m)R \dots \dots \dots (3)$$

since, this formula involves the difference of the squares of the diameters of two rings and is independent of the thickness of the air film at the point of contact 'O', the above error is minimized. If the measurements are made on bright rings of the diameter of  $n^{\text{th}}$  bright ring is given by  $D_n^2 = 2(2n+1)R\lambda$

Therefore Diameter of the ring depends upon the wavelength of light used.

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**In the figure:**

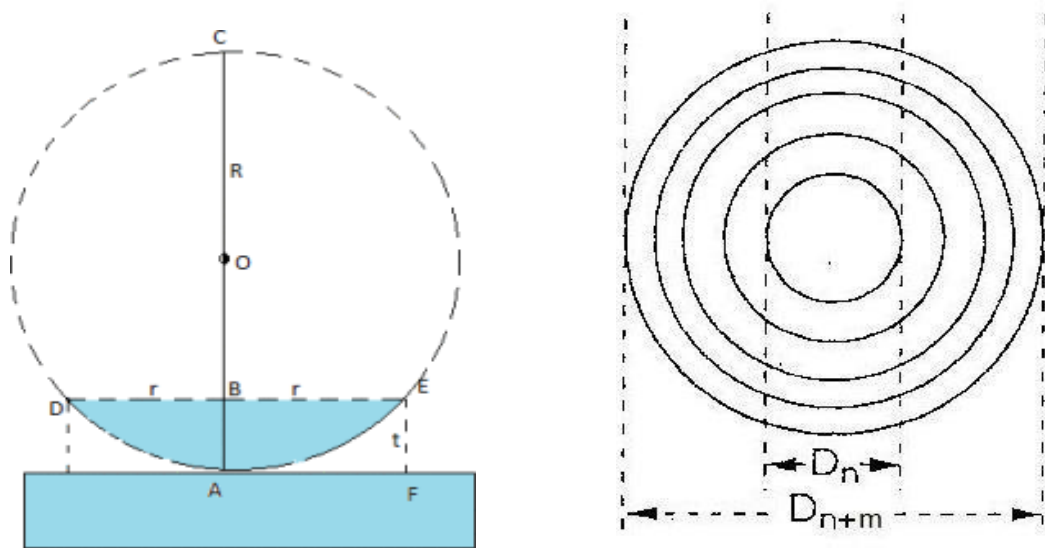


Figure 2

Here  $R$  is the radius of curvature of the lens that can be found with a spherometer using the relation

$$R = \frac{l^2}{6h} + \frac{h}{2}$$

where  $l$  is the distance between the two legs of the spherometer and  $h$  is the height or the thickness of the lens at the center.

Here, the radius of the curvature is determined by using a spherometer. In this case

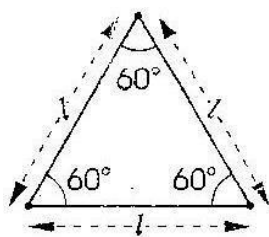


Figure 4

$$R = \frac{l^2}{6h} + \frac{h}{2}$$

where  $l$  is the radius between the two legs of the spherometer as shown in fig. (4),  $h$  is the difference of the readings of the spectrometer when it is placed on the lens as well as when placed on plane

## Physics Lab (BSP-103P)

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surface (the thickness of the lens at the center) .

### PROCEDURE:

1. Find the least count of micrometer scale.
2. Clean the surface of glass plate 'G', glass plate 'P' and the Plano-convex lens L, Put them in position as shown in Fig.1 in front of the sodium lamp.
3. Switch on the sodium lamp and see that only parallel beam of light coming from the convex lens on the glass plate 'G'
4. Adjust the position of microscope so that it lies vertically above the center of lens L2. Focus the microscope so that alternate dark and bright rings are clearly visible.
5. Adjust the position of the microscope till the point of intersection of the cross-wires coincides with the center of the ring system and one of the vertical cross-wires is perpendicular to the horizontal scale.
6. Move the microscope to the left with the help of micrometer screw so that the vertical cross wire lies tangentially at one of the extreme ends of the 20<sup>th</sup> dark ring.
7. Note the reading of the micrometer scale 'a' of the microscope.
8. Slide the microscope backward with the help of micrometer screw and go on noting the readings when the cross wire lies tangentially at the extreme ends of horizontal diameter of 16<sup>th</sup>, 12<sup>th</sup>, 8<sup>th</sup> and 4<sup>th</sup> dark rings in column 'Left (a)' respectively.
9. Continue sliding the microscope to the right and note down the readings in column 'Right (b)' when the vertical cross wires lies tangentially at the other extreme end of the diameter of 4<sup>th</sup>, 8<sup>th</sup>, 16<sup>th</sup> and 20<sup>th</sup> dark rings respectively.
10. Now slide the microscope backwards and again note down the readings corresponding to the same rings on the right and then on the left to the center of the ring system in column 'Right(c)' and 'Left(d)'.
11. Remove the Plano-convex lens L2 and find the radius of curvature of its convex surface by using a spherometer.

The radius of curvature may also be determined by plotting a graph between  $D^2$  along Y-axis and then number of the ring(n) along X-axis as explained in part-2 of the experiment.

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### Observations :

Value of one division of the main scale =

.... cm No. of divisions on the vernier

scale = ....

Least count of the microscope = ....

**Table: For the determination of  $(D^2_{n+m}-D^2_n)$**

No. of the rings	Microscope reading		Diameter r	Microscope reading		Diameter	Mean Diameter
	Left (a) cm.	Right (b) cm.	d1 =(a-b)	Right (c) cm	Left (d) cm	d2=(c-d)	$D = \frac{d_1 + d_2}{2}$
20							
16							
12							
8							
4							

Using spherometer method :

L.C. of spherometer = .... cm.

S. No.	Spherometer Reading						h = (b—a) cm.	Mean h cm.
	Zero reading on plane surface			Reading on lens				
	M.S.R.	V.S.R.	Total Reading cm. (a)	M.S.R.	V.S.R.	Total Reading cm. (b)		

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Distance between the two legs of spherometer  $l = \dots$  cms.

### **Calculations:**

Using Spherometer method:

$$R = (l^2 / 6h) + (h / 2) \\ = \dots \text{ cms}$$

The wavelength of sodium light is given by:

$$\lambda = (D_{n+m}^2 - D_n^2) / 4Rm \\ = \dots \text{ Angstrom}$$

The value of  $(D_{n+m}^2 - D_n^2)$  can also be obtained using a graph as shown in fig.(5). The graph is plotted between the square of diameter of the ring along Y-axis and corresponding number of ring along X-axis.

### **Result :**

The mean wavelength  $\lambda$  of sodium light =  $\dots$

Angstrom Standard mean wavelength  $\lambda =$

.....Angstro

m

Percentage error =  $\dots$  %

### **Sources of Error and Precautions :**

- i) Glass plates and lens should be cleaned thoroughly.
- ii) The lens used should be of large radius of curvature.
- iii) The source of light used should be an extended one.
- iv) Before measuring the diameter of rings, the range of the microscope should be properly adjusted.
- v) Crosswire should be focused on a bright ring tangentially.
- vi) Radius of curvature should be measured accurately.

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**Theoretical error:**

In our case,

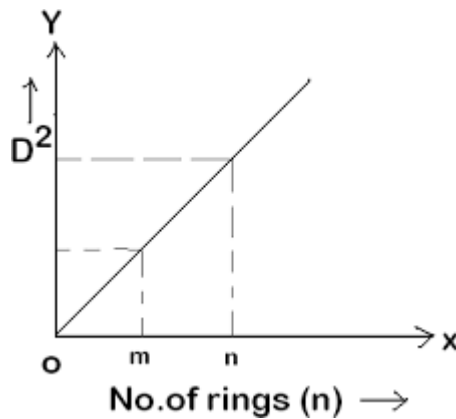
$$\lambda = (D_{n+m}^2 - D_n^2) / R$$

4Rm Taking logarithm of both sides and differentiating

$$\frac{1}{\lambda} \frac{d\lambda}{dR} = \frac{2(D_{n+m}^2 - D_n^2)}{D_{n+m}^2 - D_n^2} \frac{dR}{R}$$

$$= \frac{2\{D_{n+m}^2 (dD_{n+m}^2) - D_n^2 (dD_n^2)\}}{D_{n+m}^2 - D_n^2} \frac{dR}{R}$$

= .... %.



**Figure 5**

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### Quiz with Answers:

Q1. What is Newton's ring experiment used for?

Ans: To determine the wavelength of a light source, in this case, sodium light.

Q2. How does Newton's ring experiment work?

Ans: A lens is placed on a flat glass surface, creating interference fringes known as Newton's rings.

Q3. What causes the formation of Newton's rings?

Ans: The light waves reflecting from the top and bottom surfaces of the lens create constructive and destructive interference patterns.

Q4. What is the relation between the radius of the rings and the wavelength of light?

Ans: The radius of the rings is directly proportional to the square root of the wavelength of light.

Q5. How is the wavelength of sodium light calculated?

Ans: By measuring the diameter of several rings and using the known radius of curvature of the lens.

Q6. What are the essential components for the experiment?

Ans: A light source emitting sodium light, a plano-convex lens, and a flat glass plate.



**LAB EXPERIMENT 2**

**Aim:** To determine the wavelengths of prominent lines of mercury by plane diffraction grating.

**Apparatus required:** A plane diffraction grating, spectrometer, mercury lamp, prism, spirit level, reading lens.

**Formula used :** Wavelength of a spectral line can be calculated by 
$$\lambda = \frac{(e + d) \sin \theta}{n}$$

Where,  $e + d$  = grating element  
 $n$  = order of spectrum

**Principle:** It is based on the principle of Fraunhofer diffraction through a diffraction grating.

**Theory:** A diffraction grating has large no. of slits of equal width and separation. Let there are  $N$  parallel slits each of width  $e$  separated by opaque space  $d$ . So the grating element is  $(e + d)$ .

Let a collimated beam is incident on the grating normally as shown in Fig.1. The rays diffracted by various slits at the same angle  $\theta$  at point P on the screen/eye piece. The resultant intensity at P due to all the rays is given by

$$I = \left[ \frac{A \sin \alpha}{\alpha} \right]^2 \left[ \frac{\sin N\beta}{\sin \beta} \right]^2 \quad (1)$$

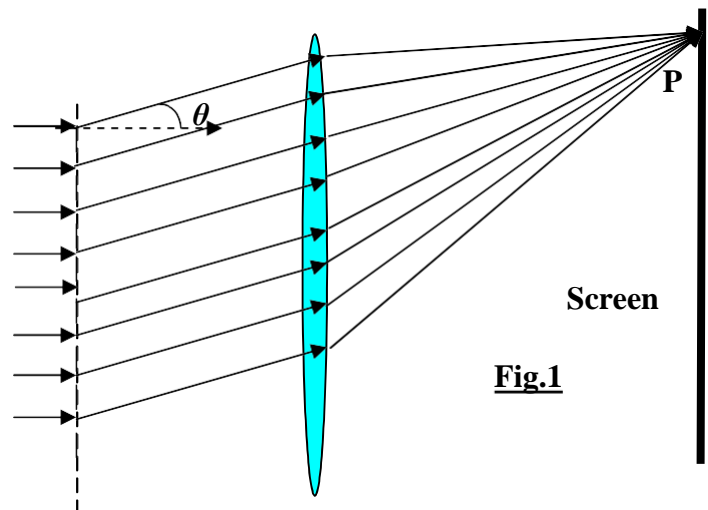
Here,  $\alpha = \frac{\pi}{\lambda} e \sin \theta \dots\dots(2),$

and  $\beta = \frac{\pi}{\lambda} (e + d) \sin \theta \dots\dots(3)$

Condition for principal maxima: I will be maximum when  $\sin \beta = 0 \Rightarrow \beta = \pm n\pi; n = 0, 1, 2, \dots(4).$

Using (3) and (4), the intensity will be maximum when,  $(e + d) \sin \theta = \pm n\lambda \dots\dots\dots(5)$

Here,  $n$  is the order of the diffraction pattern. Thus the wavelength of a spectral line can be calculated by  $\lambda = \frac{(e + d) \sin \theta}{n} \dots\dots\dots (6)$

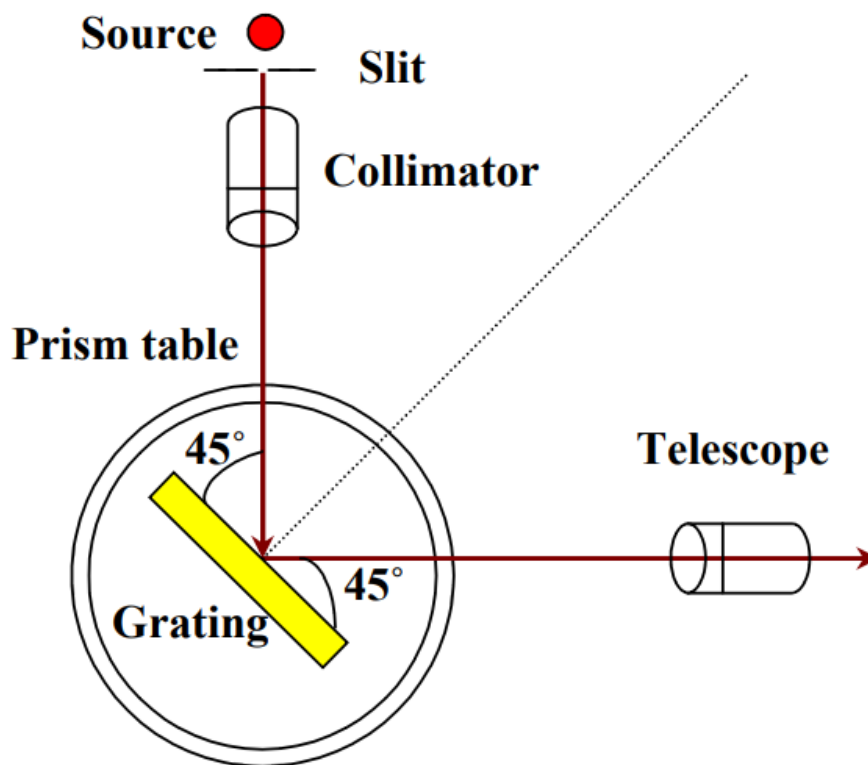


**Fig.1**

**Spectrometer Design:** The spectrometer consists of a collimator, a prism table and telescope as in above Fig.

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The collimator consists of two hollow concentric metal tubes, one (the smaller) sliding under the other. The free end of the longer tube carries an achromatic lens and that of the smaller tube has a slit adjustable width. The slit is adjusted in the focal plane of lens in order to obtain a parallel beam. The collimator also has two screws for adjusting the inclination of the axis of the collimator. The prism table is a circular table, which moves over a graduated circular scale carried by the telescope.



**Fig.2**

The relative positions of the prism table and the telescope can be read over these two vernier scales. There are three leveling screws at the lower surface of the prism table and a tangent screw for slow motion. The telescope too possesses two hollow concentric tubes like collimator. The free end of the tube facing prism table has an achromatic objective lens, and the other free end carries a eye piece along with a fine crosswire. Like prism table, the telescope can be clamped to the main body of the spectrometer. In clamped condition the telescope can be given fine motion using tangent screw.

**Procedure:** (i). All main body of the spectrometer is leveled horizontally using the screws provided at the base with the help of a spirit level. Then prism table is leveled using the three screws which support

## Physics Lab (BSP-103P)

the prism table. (ii). Adjust the slit screw to get a sharp and vertical slit.  
 (iii). Determine the least count. (iv). Mount the grating over the prism table vertically.  
 For setting the grating for normal incidence first the direct image of the slit is seen through the telescope. The readings of the two verniers are noted. The telescope is rotated on either side by 90° and clamped. The prism table is rotated so that the reflected image of the slit is seen on the crosswire through the telescope. Again take the readings of the two verniers (as in Fig.2).

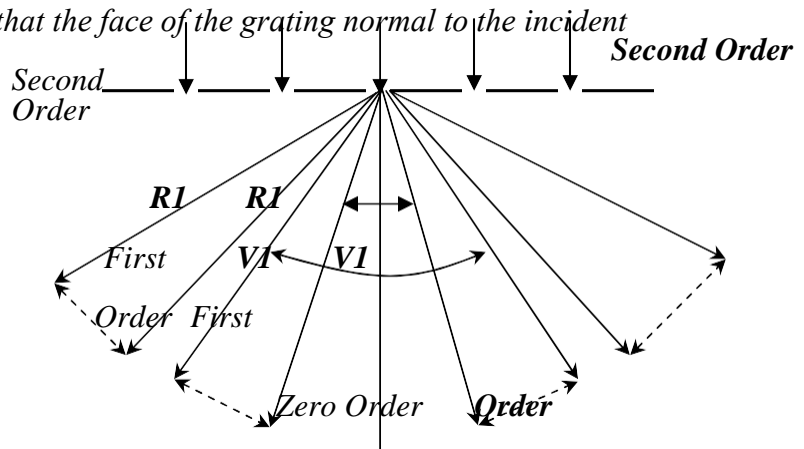
(v). Now turn the prism table from this position by 45° or 135° such that the face of the grating normal to the incident beams. Unclamp the telescope. Now set up is ready for observations.

(vi). Rotate the telescope to the left of the direct image to get the first order spectrum. (Direct image is the zeroth order). Clamp the telescope.

Adjust the different spectral lines

colourwise one by one on the

crosswire and note the readings of verniers v1 and V2 for each colour. (vii). Now rotate the telescope towards the right side of the direct image. Again get 1<sup>st</sup> order spectrum of same colours and note the readings of verniers v1 and V2 for each colour as shown in Fig.3.



**Fig.3**

(viii). Find out the difference of readings of same verniers for various colours for 1<sup>st</sup> orders, half of the angle so obtained is the angle of diffraction for that particular colour and particular order.

(ix). Determine the various wavelengths using

$$\lambda = \frac{(e + d) \sin \theta}{n}$$

## Physics Lab (BSP-103P)

**Observations:**

No. of rulings per inch on the grating,  $n = 12500$ .  $(e+d) = 2.54/12500$  cm =

**(a). Determination of the least count of the Spectrometer**

Value of one Main Scale Division,  $x =$                       Degree,

Total no. of divisions in circular scale,  $n =$                       .

Hence, least count of the microscope screw =  $x/n =$                       Degree

**(b). Table for the determination of angle of diffraction for 1<sup>st</sup> order spectrum**

Colour of light	No. of Vernier	Spectrum on left, Reading of telescope			Spectrum on right, Reading of telescope			$\theta = (a-b)/2$	Mean $\theta$ , Degrees
		M.S.	V.S.	Total, (a) Degrees	M.S.	V.S.	Total, (b) Degrees		
Blue	V1								
	V2								
Green	V1								
	V2								
Yellow	V1								
	V2								
Red	V1								
	V2								

**Result:** wavelengths of various lines of mercury light are given below.

Colour	Standard wavelength, Å	Observed wavelength, Å
Blue	4693	
Green	5461	
Yellow	5770	
Red	6238	

## Physics Lab (BSP-103P)

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- Uses:** (1) To determine the wave length of light used.  
(2) To study the spectra of different sources of light.

### **Source of error and Precautions:**

- (i). Spectrometer leveling and adjustments should be properly done. (ii). Setting up the collimator and telescope for parallel rays is essential.  
(iii). The formula used is for normal incidence of light on grating, hence this adjustment should be accurately done.  
(iv). The slit should be sharp and vertical, i.e., parallel to the rulings on the grating.

### **Quiz with Answers:**

Q1. What is the plane diffraction grating used for?

Ans: To determine the wavelengths of prominent lines in the spectrum of a light source, such as mercury.

Q2. How does the plane diffraction grating work?

Ans: The grating disperses light into its component wavelengths, creating a spectrum with distinct spectral lines.

Q3. What are the essential components for the experiment?

Ans: A plane diffraction grating, a light source emitting mercury light, and a screen to observe the spectrum.

Q4. How does the plane diffraction grating disperse light?

Ans: The grating consists of closely spaced parallel lines that act as slits, causing light to diffract and interfere, creating a spectrum.

Q5. What is the formula to calculate the wavelength of spectral lines?

Ans: Wavelength ( $\lambda$ ) =  $d \cdot \sin\theta$ , where  $d$  is the grating spacing and  $\theta$  is the angle of diffraction.

## LAB EXPERIMENT 3

**Aim:** To study Hall Effect by determining the Hall Voltage and Hall Coefficient

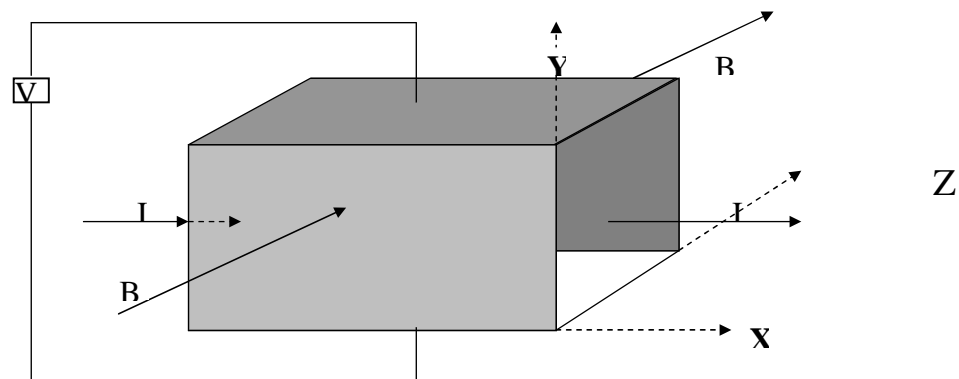
**Apparatus required:** Hall probe with Germanium (Ge) crystal, Hall Effect set up, Electromagnet, a constant current source, Gauss meter.

**Formula used:** -Hall coefficient  $R_H = \frac{t}{\text{coulomb}} \tan \phi \cdot \text{cm}^3 / B_y$

Where t = thiknes  
B = Magnatic fild.

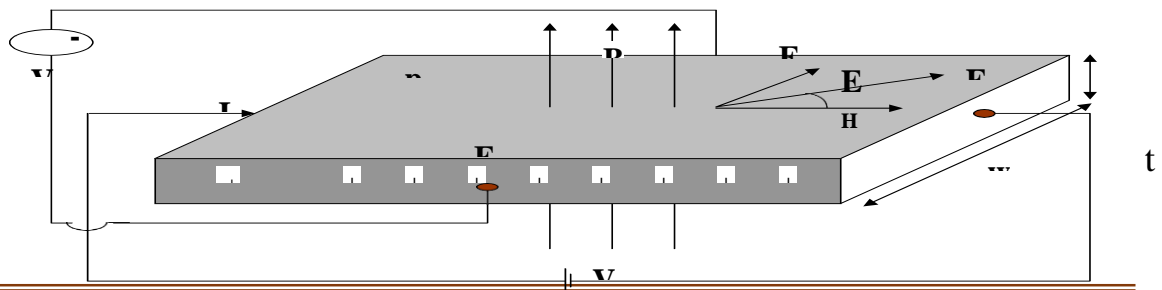
**Theory:** If a metal or a semiconductor carrying a current is placed in a transverse magnetic field, a potential difference is produced in the direction normal to both the current and magnetic field direction.

□ **Hall Effect.**



In the Fig. above, the electric field is applied along X-direction; magnetic field is in Z-direction. Hence, a potential difference due to Hall Effect is developed in the rectangular sample along Y- direction. For a rectangular plate of a p-type semiconductor when a potential difference is applied for the application of electric field at the ends of it a current 'I' flows through it along X-direction as shown in Fig. Hence the current due to charge carrier 'holes' in p-type semiconductor is given by,

$$I \propto peA \dots \dots \dots (1)$$



## Physics Lab (BSP-103P)

Here,  $p$  is concentration of holes in atoms/cc,  $A$  is the cross sectional area of the end face,  $e$  is the charge of a hole. By applying the external electric field now the potential difference between the front and rear faces  $F$  and  $F'$  is zero, as this plane along  $FF'$  is perpendicular to the plane of electric field. However, on application of  $B$  normal to the crystal surface and to the current flow, a transverse potential difference is produced between  $F$  and  $F'$ . This is called the Hall Voltage,  $V_H$ . If  $t$  be the thickness of the plate (as in 2<sup>nd</sup> Fig.), then,  $A=wt$ . Hence,  $V_H = \frac{wBI}{pet} = \frac{BI}{pe}t$  ----- (1)

□

### Hall Coefficient

► The Hall Coefficient,  $R_H$ , is defined as the Hall Field per unit magnetic induction per unit current density. Hence,  $R_H = \frac{E_H}{BJ_x} = \frac{V_H w}{BJ_x} = \frac{BI}{wB(I/wt)} = R_H = \frac{1}{pe}$  ----- (2)

► From (1) and (2),  $V_H = R_H \frac{BI}{t} = R_H \frac{tV_H}{BI}$  ----- (3)

When the directions of  $B$  and  $I$  are like the directions as shown in Fig. before, the sign of  $V_H$  is positive. However, for an n-type semiconductor  $V_H$  is negative for same directions of  $B$  and  $I$ . So by knowing the polarity of Hall voltage the type of a semiconductor can be known. Knowing the value of  $R_H$  (from (3)), the concentration of charge (majority) carriers can be determined (using (2)).

### Procedure:

- (i). The specimen is placed in the field (between the poles) of electromagnet.
- (ii). Constant current,  $I_x$ , is passed through the sample along X-axis.
- (iii). The magnetic field ( $B_y$ ), already measured in a Gauss meter, is directed along Y-axis.
- (iv). The Hall voltage ( $V_H$ ) developed in the sample is measured.
- (v). Steps (ii) to (iv) are repeated for different values of  $I_x$ .
- (vi). A straight line graph is plotted between  $I_x$  and  $V_H$ .
- (vii). The slope of this curve,  $\tan^{-1} \frac{V_H}{I}$ , is then calculated.

(viii). The value of  $R_H$  is then calculated by using eqn.(3) as  $R_H = \frac{t}{B_y} \tan^{-1} \frac{V_H}{I}$ .

## Physics Lab (BSP-103P)

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### Observations:

Table to plot graph between  $I_x$  and  $V_H$   
 $t = 0.55 \text{ mm}$ ,  $B_y = \text{Gauss}$ .

Sr. No.	Applied current, $I_x$ , mA	Hall voltage, $V_H$ , mV	Sr. No.	Applied current, $I_x$ , mA	Hall voltage, $V_H$ , mV
1			8		
2			9		
3			10		
4			11		
5			12		
6			13		
7			14		

**1. Calculations:** From the slope of the graph between  $V_H$  and  $I_x$  we have,

$$\tan \theta = \frac{V_H}{I_x} = \frac{R}{t} \quad \text{and, Hence, } R = \frac{t}{\tan \theta}$$



## Physics Lab (BSP-103P)

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$\square I_x$

$H \quad B_y$

### Result:

The value of Hall Coefficient,  $R_H$ , is.....cm<sup>3</sup>/ coulomb. .

### Precautions:

- (i). The dimension of the crystal slab should be accurately measured.
- (ii). Measurement of  $V_H$  &  $B_y$  has to be very accurate.

### Quiz with Answers:

#### Q-1 What is hall effect?

**Ans:** If a current carrying conductor (or semiconductor) is placed in a transverse magnetic field a voltage is produced perpendicular to both the direction of the current and the direction of magnetic field. The voltage so developed is called Hall voltage and the phenomenon is called the Hall effect.

#### Q-2 What is hall coefficient?

**Ans:** Hall coefficient is defined as the ratio of hall electric field per unit current density and the transverse magnetic field.

#### Q-3 What is the use of hall effect?

**Ans:** It is used in the determination of Hall coefficient.

#### Q-4 On what factors the sign of Hall potentials depends.

**Ans:** It depends upon the nature of charge carriers. Thus by noting the directions of Hall potential and magnetic field, the nature of the charge carriers may be determined by the use of Flemming's left hand rule.

#### Q-5 What is mobility?

**Ans:** It is the drift velocity of the charge carrier acquired per unit electric field.

### LAB EXPERIMENT 4

**Aim:** To find frequency of AC mains using sonometer.

#### **Apparatus/Material Required**

- A Sonometer (with soft iron wire)
- A set of eight Tuning Forks
- Seven ½ kg slotted weights
- A step-down transformer
- A Clamp
- Rubber pad
- Paper rider
- A Meter scale.

#### **Theory**

Let us consider the alternating current to have a frequency  $\nu$  so that the frequency of magnetisation of the electromagnet  $V_E$  becomes  $2\nu$ .

Let a loaded stretched soft iron wire have a resonant length  $l_1$  with the electromagnet. Let a tuning fork of frequency  $V_T$  have resonant length  $l_2$ .

From the law of length,

$$V_E l_1 = V_T l_2$$

$$\text{or } V_E = V_T (l_2/l_1)$$

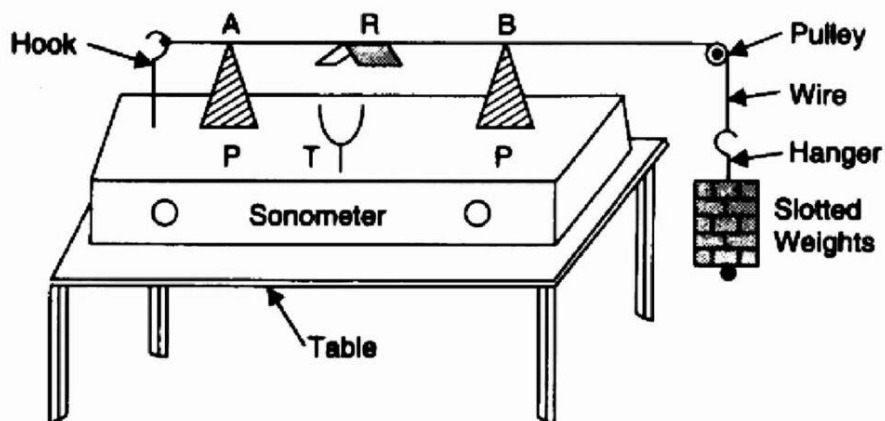
Hence frequency of alternating current which can be calculated by the given formula,

$$V = (1/2)V_E = \left[ \left\{ (1/2)V_T \right\} l_2/l_1 \right]$$

The Natural frequency of oscillation for a stretched wire of length  $L$  mass  $m$  and Tension  $T$  is given by,

## Physics Lab (BSP-103P)

$$n = \frac{1}{2L} \sqrt{\frac{T}{u}} \text{ here } u = \frac{\text{mass}}{\text{length}} = \frac{m}{L}$$



**Figure :** Sonometer in experimental set up to find frequency of AC mains

### Procedure

1. Set up the Sonometer on the table as shown in figure.
2. Test the pulley and make it frictionless by oiling (if necessary).
3. Put suitable maximum weights in the hanger.
4. Move wooden bridges P, P outward to include maximum length of wire (AB) between them.
5. Decrease the length of the wire by moving both the bridges equally inwardly.
6. Go on decreasing the length till sonometer wire starts vibrating (a sound is heard).
7. Switch on the alternating current supply and adjust the length of vibrating portion of AB by sliding the wedge W or W'. Make this adjustment until the amplitude of the vibrating string is maximum.
8. Measure the length of the wire AB between the edges of the two bridges and record it in 'length decreasing' column.
9. Bring the two bridges closer and then adjust the length for maximum amplitude by increasing it.
10. Measure the vibrating length and note the tension in the string then record it in length increasing column.
11. Now take a tuning fork of minimum known frequency and adjust the wire length with the vibrating tuning fork.
12. Repeat step 11 above with tuning forks of other known frequencies 288-512.
13. Record the observations.

## Physics Lab (BSP-103P)

### Observations

- The weight suspended to produce on the wire  $T = \text{--- kg}$ .
- The Length of the Sonometer wire  $L = \text{--- m}$ .
- Mass of the wire  $m = \text{--- kg}$ .
- Linear Density  $u = m/L \text{ kg/m}$ .

### Observation Table for Frequency and Length:

Table for frequency and length						
Serial No. of Obs. (1)	Frequency of electromagnet and tuning forks used $\nu$ (Hz) (2)	Resonant length of wire			Frequency of electromagnet $\nu_E$ (Hz) (4)	$n = \frac{l}{2L} \sqrt{\frac{T}{\mu}}$ (5)
		Length decreasing $l'$ (cm) (3a)	Length increasing $l''$ (cm) (3b)	Mean = $\frac{l' + l''}{2}$ $l$ (cm) (3c)		
1.	$\nu_E$			$l_1 =$		
2.	256			$l_2 =$	$256 \frac{l_2}{l_1} =$	
3.	288			$l_3 =$	$288 \frac{l_3}{l_1} =$	
4.	320			$l_4 =$	$320 \frac{l_4}{l_1} =$	
5.	384			$l_5 =$	$384 \frac{l_5}{l_1} =$	
6.	480			$l_6 =$	$480 \frac{l_6}{l_1} =$	
7.	512			$l_7 =$	$512 \frac{l_7}{l_1} =$	

Table: Frequency of the AC mains with a sonometer observation table

### Calculations

- Using the formula,  $\nu_E = \nu_2(l_2/l_1)$ , calculate  $\nu_E$  with observations 2 to 7.
- Record these values in column 4 of the table.
- Find the mean of the above six values of  $\nu_E$ .
- Then the frequency of the alternating current can be determined by the formula,  $\nu = \nu_E/2$ .
- Use  $n=1/2L\sqrt{T/u}$  for each set of observation and then take the mean, compare it with standard frequency (50Hz).

### Result

## Physics Lab (BSP-103P)

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- The frequency of alternating current = \_\_\_ Hz.

### Percentage Error:

- The actual frequency = 50 Hz.
- Difference = \_\_\_ Hz.
- Percentage error =  $(\text{Difference}/\text{Actual Value}) \times 100\%$   
The error is within limits of the experimental error.

### Precautions

- All the precautions of sonometer experiment should be observed.
- Pulley should be as frictionless as possible.
- The wire should be of soft iron or of any other magnetic material.
- Tip of the electromagnetic pole should be very close to the middle of the sonometer wire.
- Length should be noted when the amplitude of vibration is maximum.
- After taking each of the observations, circuit should be switched off for a few minutes.

### Sources of Error

- Friction of the pulley is the main source of error in the experiment, due to this, the value of tension acting on the wire is less than that actually applied, so pulley may not be frictionless.
- The wire may not be rigid and of uniform cross-sectional area.
- Weights may not be correct.
- The knife edges (bridges) may not be sharp.
- The AC frequency may not be stable.

### Quiz with Answers:

Q1. What is a sonometer used for in this experiment?

Ans: To measure the frequency of the alternating current (AC) mains.

Q2. How does the sonometer measure the frequency of AC mains?

Ans: By comparing the frequency of the AC mains with the natural frequency of a vibrating string on the sonometer.

Q3. What components are required for the experiment?

Ans: A sonometer with a vibrating string, an AC power supply, and a frequency counter or a tuning fork with a known frequency.

Q4. How is the sonometer set up for the experiment?

## Physics Lab (BSP-103P)

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Ans: The sonometer string is plucked, and the AC power supply frequency is adjusted until resonance occurs.

Q5. What is the principle behind using the sonometer for frequency measurement?

Ans: When the frequency of the AC mains matches the natural frequency of the sonometer string, resonance is achieved, resulting in a clear and loud sound.

# Physics Lab (BSP-103P)

## LAB EXPERIMENT 5

**Aim:** - To determine the hysteresis loss by C.R.O.

**1. Apparatus required:** - A step down transformer specimen transformer hysteresis loss of which is to be calculated, capacitor ( $8\mu\text{F}$ ), resistor ( $50\text{ K}\Omega$  potentiometer), A.C. Voltmeter (0-10), A.C. millimeter (0-500mA), Rheostat ( $10\Omega$ ).

**2. Formula used:** - 
$$\text{Energy loss} = \frac{0.5N \times S \times V \times S_H \text{ Area of loop}}{R \times L} \quad \text{joules/ cycle/ unit volume.}$$
$$\text{Area of loop} = \frac{\text{No. of small squares}}{100\text{cm}^2}$$

Where,

N is the number of turns of sample coil

R is the value of the resistance,

L is the length of specimen in meters,

$V_x$  is the applied voltage to the horizontal X plate.

**3. Theory:** - The flux density B is the ratio of total no of lines of force existing in the magnetic field (in webers) and the area (in  $\text{m}^2$ )

$B = \text{Total no of lines of force (Wb)} / \text{Area (m}^2\text{)}$

The permeability ( $\mu$ ) is the ratio of the change in flux density to the change in field intensity.

$\mu = \frac{\text{change in flux density}}{\Delta K} / \text{change in field intensity} = \frac{\Delta B}{\Delta K}$

Materials like cobalt, nickel, iron which possess a value of  $\mu$  much greater than unity are called ferromagnetic materials. Materials with  $\mu$  less than unity are called diamagnetic, while materials with  $\mu$  values slightly greater than unity are called paramagnetic. For vacuum, the value of permeability is unity. When an alternating current is allowed to flow through an air core coil the variation of flux density (B) with magnetizing force (H), the flux density increases in phase with the magnetizing force. If H is now decreased "I" also decreases but following a path AB. Thus "I" lags behind H becomes zero; "I" still has a value OB. This amount of magnetization is called the "**Residual Magnetism**" or "**Retentivity**" of the specimen. Thus the retentivity of a specimen is a measure of the intensity of magnetization remaining in the specimen when the magnetizing field is removed. If the magnetizing field H be now increases in the reverse direction, the value of 'I' further decreases, still lagging behind H and become zero when H has a value equal to OC. This value of magnetizing field is called the "**Coercive force**" or "**Coercivity**" of the specimen. Thus coercivity is a measure of the magnetizing field required to destroy the residual magnetism of the specimen.

As H is increased beyond OC, the specimen is increasingly magnetized in the negative direction, until the magnetic saturation is reached at D. by taking H back from its negative saturation value, through zero, to its original positive saturation value, a similar curve DEFA is obtained.

## Physics Lab (BSP-103P)

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It is thus found that the intensity of magnetization 'I' always lags behind the magnetizing field H when H changes. The lagging of 'I' behind H called "**Hysteresis**". The closed curve ABCDEF A which represents a cycle of magnetization if specimen is known as "**Hysteresis Curve**" of the specimen. A graph between magnetic induction B and magnetizing field H is similar in shape with the only difference that B never becomes constant but always increases with H. Hence in the B-H curve, the corners A and D are not straight but sloping.



## Physics Lab (BSP-103P)

The magnetic field H

$$H = \frac{NI}{L} \text{ ampere turns/meter.}$$

Similarly the flux density decrease with the magnetizing force in face. However for an iron cored coil or a coil consisting of a core of ordinary steel the B-H curve or magnetization curve of the iron core forms a loop called hysteresis loop. Saturable reactor normally uses cores of nickel iron or silicon iron alloys. These materials may be of (a) thin lamination to reduce eddy currents loss. (b) Construction without gap to minimize flux leakage.

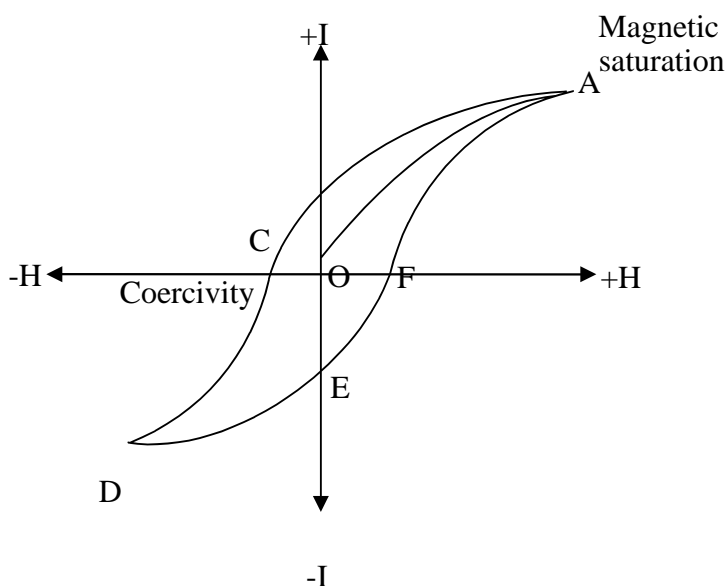


Fig. 1.

**RETENTIVITY, COERCIVITY AND HYSTERESIS:** Ferromagnetic materials contains large no of regions, called domain. In each domain, all the atomic magnets are fixed in rigid parallelism. Thus each domain has a net magnetization in a particular direction distributed randomly. When a specimen of a ferromagnetic material is placed in a magnetizing field (H), the specimen is magnetized by induction. As the magnetizing field (H) varied, the intensity of magnetization of specimen, “I” changes. The variation in “I” with variation in H is shown in fig. (1). The point O represents unmagnetised specimen and a 0 magnetizing field. As H is increased, “I” also increases but not uniformly. When all the domains are aligned in the field direction, the magnetization of specimen gets saturated at A. any further increase in H result no more increase in “I”.

## Physics Lab (BSP-103P)

### 4. CIRCUIT DIAGRAM:-

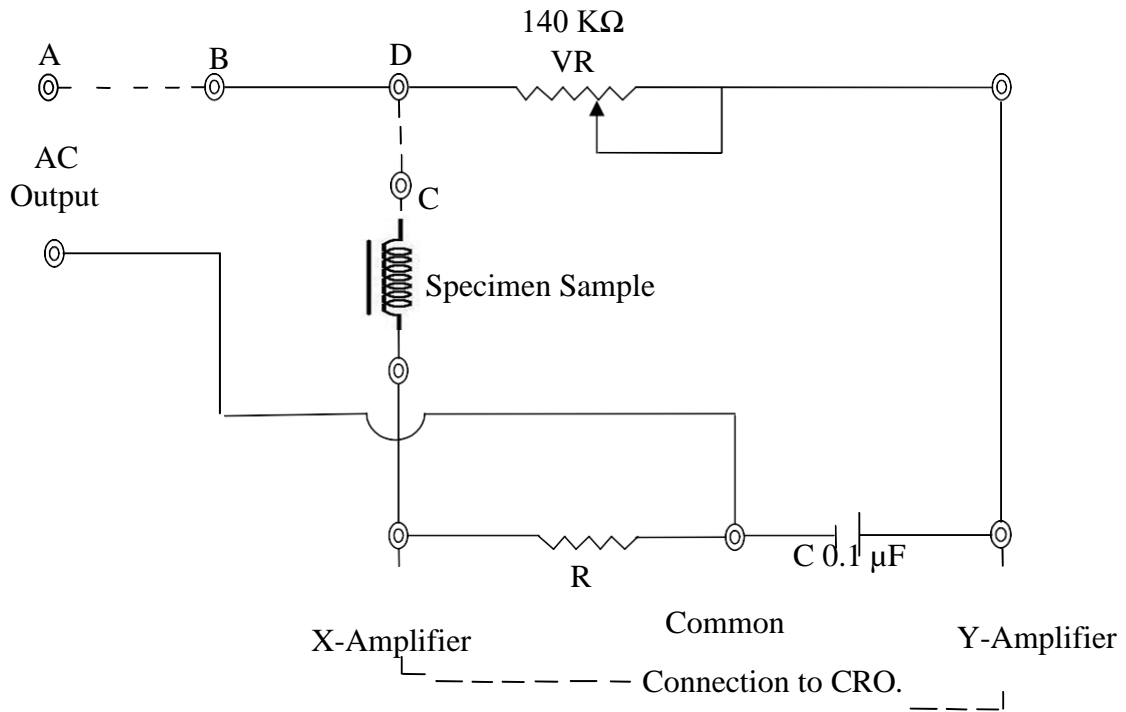


Fig. 2.

### 5. Observations:

**N** = No. of turns in the coil = 300

**S<sub>v</sub>** = Vertical sensitivity =-----

**S<sub>h</sub>** = Horizontal sensitivity =-----

**L** = 3.3cm.

**R** =----- KΩ

### 5. Result :

$$\text{Area of the loop} = \frac{\text{No. of CNASS} \times \text{cquarec}}{100 \text{ CN}}$$

Energy loss = -----Joules / cycle / cc.

## Physics Lab (BSP-103P)

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### Quiz with Answers:

Q. 1 What is hysteresis?

**Ans.** We observe that though the magnetizing field becomes zero yet the intensity of magnetization does not become zero. This lagging of intensity of magnetization behind the magnetizing field is called hysteresis.

Q. 2 What do you mean by hysteresis loss?

**Ans.** It has been observed that when we magnetize a magnetic material, certain amount of work is to be done i.e. energy is spent in magnetization. The same work is not recovered when the magnetizing field switched off. Thus this balance of energy left with the specimen, which is lost as heat, is called hysteresis.

Q.3 Why is the work not totally recovered?

**Ans.** Because some molecular magnets do not come back in their pre-magnetization orientation. This is due to retentivity.

Q. 4 What is retentivity?

**Ans.** The value of intensity of magnetization ( $I$ ) for which the magnetizing field is zero is called retentivity.

Q. 5 What is corecivity?

**Ans.** The value of intensity of measures of magnetic field required to make the residual magnetism to zero.

Q. 6 What is intensity of magnetization?

**Ans.** It is the magnetic moment per unit volume of the specimen of the material.

## LAB EXPERIMENT 6

**Aim:** To draw the V-I characteristic of a solar cell under constant illumination and to determine its fill factor.

**1. Apparatus required:** Solar cell, d.c.voltmeter, d.c.ammeter, resistance box, one way keys, connecting wires.

### 2. formula used:

(i) Maximum Power =  $V_m \times I_m$

(ii) Ideal power =  $V_{oc} \times I_{sc}$

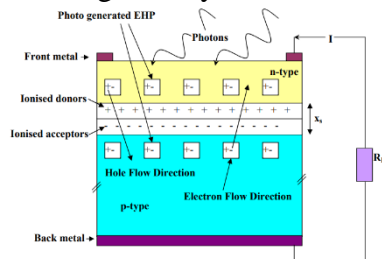
Where, (iii) Fill Factor =  $\frac{V_m \times I_m}{V_{oc} \times I_{sc}}$

**$V_m$  = Max. Voltage,  $I_m$  = Max. Current,  $V_{oc}$  = Open circuit Voltage,  $I_{sc}$  = Short circuit Current.**

**3. Theory:** Solar cell is a device which directly converts light energy to electricity. Becquerel in 1839 discovered this phenomenon of development of a voltage or potential difference under the effect of light (photons). This phenomenon is called Photovoltaic effect. Devices based on this effect are known as **Photovoltaic Cells**. A Solar Cell is a device based on Photovoltaic effect.

### Construction

The solar cells generally consists of a p-n junction, where onto its base p-region an n-region is diffused as



shown in Fig. above. It can be other way also. The bottom side is totally covered and the front side is partially covered by a metal layers.

## Physics Lab (BSP-103P)

Metal layers are used to collect all the photo generated carriers generated into the diode materials. Front side is partially covered ( $\approx 5 - 7 \%$ ) to allow more light to incident on the front surface to generate more carriers.

The diode materials generally used are semiconductor materials like gallium Arsenide (GaAs), Cadmium Telluride (CdTe), etc. However, most commonly used materials are Silicon, both in single or multi crystalline form. When a solar cell is exposed to sunlight the photons with energy,  $h\nu$ , greater than  $E_g$  of the semiconductor material are absorbed in the cell. In this process a fraction of  $E_g$  of photon energy is utilized in creating EHP and the excess energy,  $h\nu - E_g$ , is dissipated generally in the form of thermal energy given to the crystal. In a pn junction solar cell the incident photons generate EHP in both p and n regions of the junction as shown in Fig. below. The EHP thus produced in the vicinity of the junction and in the space charge region ( $x_s$ ) at the junction is separated by the strong built-in electric field that exists at the junction. This causes the photo generated electrons of the p-side to flow due to diffusion; they reach the junction and crossover to the n-side. Similarly the photo generated holes of the n-side cross over to the p-side. This accumulation of electrons on n-side and holes on p-side of the junction gives rise to a photo voltage.

► The photo voltage attains a maximum value when there is infinitely large load across the cell such that the output current of the cell is zero. This is the maximum photo voltage and is known as the **Open Circuit Voltage ( $V_{oc}$ )**.

► If a finite load resistance,  $R_L$ , is connected across the cell, current flows through it and there is a voltage drop also across the load.

► When the load connected across the diode terminals is zero, the current is maximum and is known as **Short Circuit Current,  $I_{sc}$** .

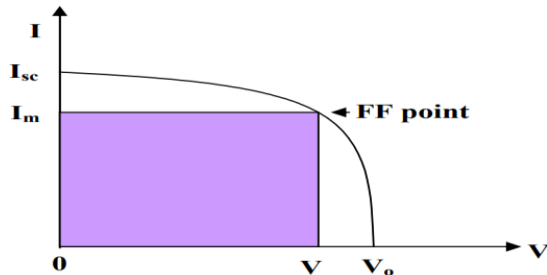
► For a finite value of  $R_L$  the current continues to flow in the circuit as long as the solar cell is exposed to sunlight, its magnitude being higher for a higher intensity of light. The photocurrent,  $I$ , which flows through the solar cell and the load is given by

$$I = I_{sc} - I_d \text{ ----- (1). Here, } I_d = I_0 \left[ e^{\frac{V + IR_s}{nkT}} - 1 \right] - \frac{V + IR_s}{R_{sh}} \text{ ---- (2)}$$

Here, junction voltage,  $V_j = V + IR_s$ , and  $V$  is the voltage developed across the load  $R_L$ ,  $I_d$  and  $I_0$  are the diode and reverse saturation current of the cell respectively,  $n$  is diode ideality factor. Here  $R_s$  and  $R_{sh}$  are the series and shunt resistances of the cell respectively. The ideal values of  $R_s$  and  $R_{sh}$  are zero and infinite respectively. However, in all practical solar cells it is difficult to achieve these values.

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Under open circuit condition  $V_{oc}$  can be expressed as  $V_{oc} = \frac{nkT}{q} \ln \left[ \frac{I_{sc}}{I_0} + 1 \right]$  ----- (3)



The condition of maximum power is  $\frac{d(IV)}{dV} = 0$  ----- (4). Eqn. (3) in conjunction with Eqn. (1) gives the value of maximum power output,  $P_m$ , under ideal condition (i.e.,  $R_s = 0$  and  $R_{sh} = \infty$ ) as  $P_m = I_m V_m$  ----- (5). Here,  $I_m$  and  $V_m$  are the values current and voltage of the cell at maximum power point. The curve factor (CF) or Fill Factor (FF) of the illuminated I-V characteristics of the cell is defined as,  $FF = \frac{P_m}{I_{sc} V_{oc}}$  ----- (6)

FF is a measure of how squarish is the I-V characteristics of the cell. However, FF is always less than 1. Larger the value of FF more squarish is the I-V characteristics of the cell. Increase in  $R_s$  and decrease in  $R_{sh}$  results in degradation of FF. FF basically denotes the maximum power rectangle inside the curve as also clear from the above Fig. An ideal solar cell characteristic curve lays in fourth quadrant due to the flow of the minority carriers only and hence is negative. However, for simplicity we draw it on the first quadrant as shown in Fig. above.

### 4. Procedure:

- (i). Keep the solar cell under light so that the light falls normally on it.
- (ii). Make circuit connections as shown in Fig. next.

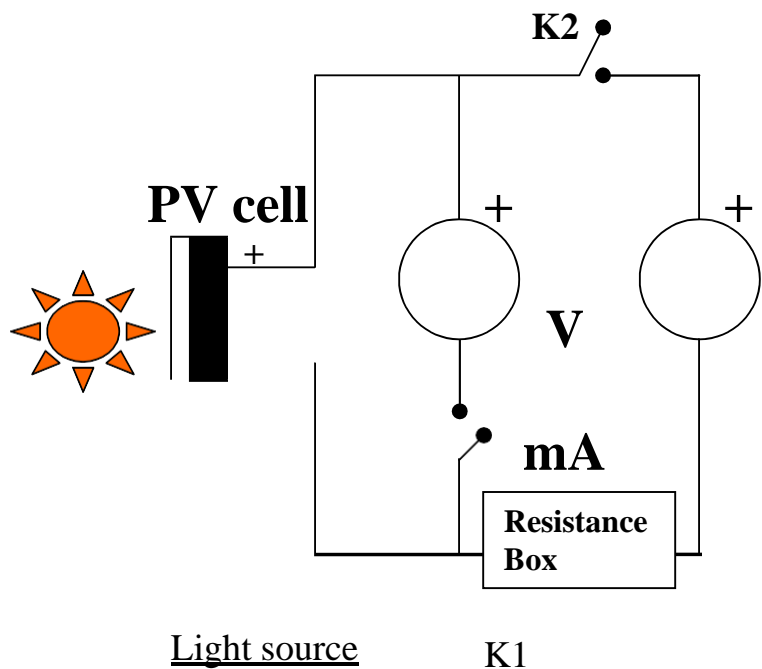
(iii). Switch on the light source & close key K1. Note the reading of voltmeter. This is  $V_{oc}$ .

(iv). Open K1 & and close K2. Make the resistance in resistance box as zero and note the reading in ammeter. This is  $I_{sc}$ .

(v). Now close both K1 & K2. Introduce resistance from resistance

box in steps and note the voltmeter and ammeter readings for each value of resistances.

(vi). Remove K1 & K2 and switch of the light source.



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### 5. Observations:

Open circuit voltage ( $V_{oc}$ ) =                      Volts; Short circuit current ( $I_{sc}$ ) =                      mA

Sr. No.	Resistance ( $\Omega$ )	Readings of		Power output, VI ( $\mu$ W)
		Voltmeter, V (V)	Ammeter, I ( $\mu$ A)	
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

### Results :

(i). Draw the graph between V along X-axis and I along Y-axis.

(ii). Mark the point at which power output, obtained from previous table, is maximum. This is the fill factor point.

(iii). **Determination of the fill factor.**

Value of voltage at maximum power output point from the table =  $V_m$  =                      V.

Value of current at maximum power output point from the table =  $I_m$  =                      mA.

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So, Fill factor =

$$V_{oc} \times I_{sc} \frac{V_m \times I_m}{V_{oc} \times I_{sc}} = \dots$$

### Precautions:

- (i). The light from source should fall normally on the cell.
- (ii). Light exposure time should be optimum as over exposure of light will heat the cell, which subsequently degrade the cell performance.

### Quiz with Answers:

Q1. Define solar cell.

Ans. A solar cell is a device which is basically a P-N junction diode which converts solar energy into electrical energy.

Q 2. Define fill factor.

Ans. It is the ratio of Maximum useful power to the ideal power.

$$\text{Fill Factor (FF)} = \frac{V_m \times I_m}{V_{oc} \times I_{sc}} \quad \underline{\hspace{2cm}}$$

Q 3. What happened to a photon when it is absorbed by a solar cell?

Ans. If the energy of the photon is greater or equal to the band gap energy than it may generate a electron-hole pair. If the energy is less than the band gap energy, it produce excitation.

Q 4. What is the conversion efficiency range of a silicon cell?

Ans. 10 to 15 %

Q 5. What is the range of fill factor for silicon?

Ans. 0.65 to 0.80



# Physics Lab (BSP-103P)

## LAB EXPERIMENT 7

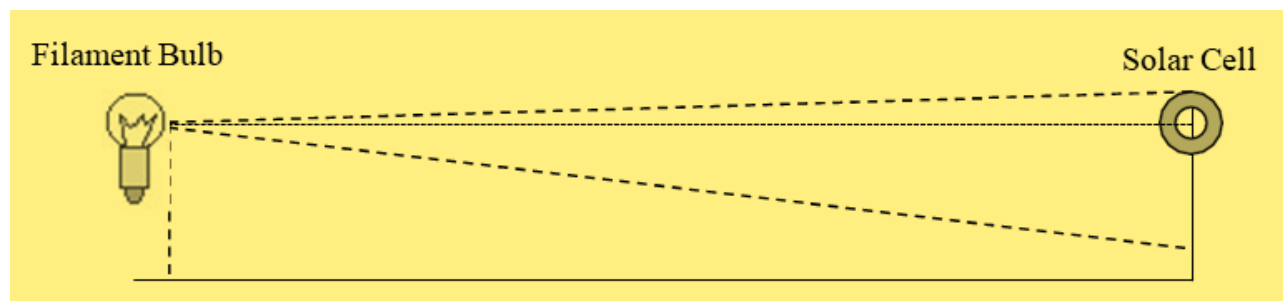
### PLANCK'S CONSTANT CHARACTERISTICS

**Aim:** To determine Planks constant using photocell.

**Apparatus used:** The complete experimental arrangement as shown in figure (1) consists of filament bulb, its power supply (0-12 V d.c.) , A solar cell fitted on mini optical bench, one Ammeter ( 0- 2 A) and one voltmeter (0-10 V) to read filament current and voltage, one digital D.C. Microammeter (0-200  $\mu$ A.).



**Planck's Constant Set-Up**



## Physics Lab (BSP-103P)

Figure 1(a)

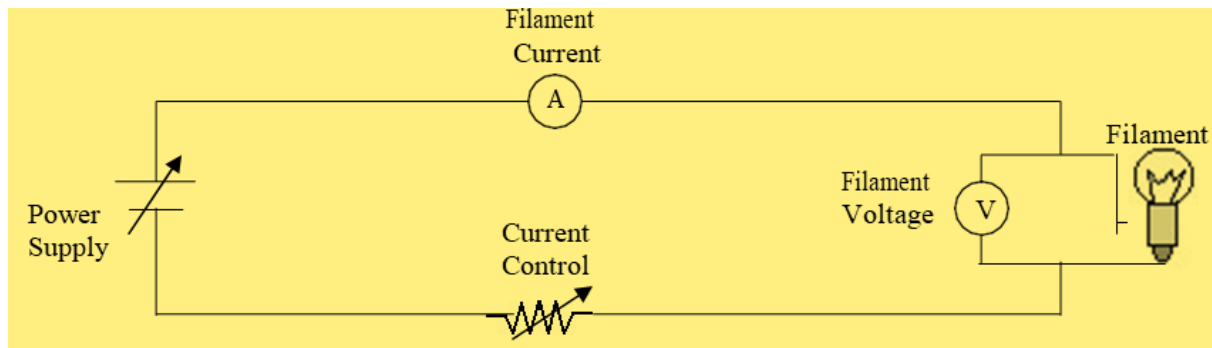


Figure 1(b)

**METHOD:-**

**To determine the value of  $R_g$  and  $R_t/R_g$  with the V-I characteristics of Bulb.**

**To find  $R_g$  the resistance of the filament bulb when it just starts glowing:** Connect the set-up with the mains and switched it ON. Apply filament current by the power supply control knob marked CONTROL on the panel such that the filament just starts glowing. Note the corresponding filament current and voltage and record these readings in table-I as shown below. Take at least three readings to get the better value of  $R_g$ . **Refer fig. 3**

**TABLE: - I For  $R_g$ , the resistance of the filament when it just starts glowing.**

S.No.	Filament Current	Filament Voltage	$R_g$ Ohm	Average $R_g$
	I Amp.	V Volt		
1				
2				
3				

**1. To find  $R_t/R_g$  from the V-I characteristics of bulb:** Further increase the filament current in steps of 0.1 amp. and note the corresponding values of filament voltage for each value of filament current. Record all these readings in table-II as shown below.

**2.** Calculate  $R_t$  and  $R_t/R_g$  for each value of filament current and voltage.

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**TABLE: - II For V-I Characteristics of the Filament bulb**

S.No.	Filament Current I Amp.	Filament Voltage V Volt	$R_t$ Ohm	$R_t / R_g$
1.				
2.				
3.				
4.				

**(a) Observations of  $\theta$  and to determine the value of Planck's constant 'h'**

- Adjust the filament bulb at some distance 'd' from the solar cell on mini optical bench.
- Increase the filament current to such extent that the digital micro ammeter reads some photo-current say mini  $2 \mu\text{A}$  to  $3 \mu\text{A}$ . Note this value of filament current and photocurrent and record it in table- II as shown below.
- Increase the filament current in steps of 0.1 amp. As in previous case and note the corresponding photo-current for each value of filament current. Record these readings in table- III.
- Note the value of  $R_t / R_g$  for each value of filament current from table-II and record these readings in table -III.
- Note the corresponding temperatures for each value of  $R_t / R_g$  from graph no I or table-IV for  $R_t / R_g$  Vs Temp T °K for tungsten.
- Calculate  $\log \square$  and  $1/T$  °K.
- Plot graph between  $\log \square$  Vs  $1/T$ °K and find the slope of the curve.
- Repeat the experiment at different value of 'd' between the bulb and solar cell.

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**Table-III For  $\theta$**

For distance between the filament bulb and solar cell  $d = \quad \text{cm}$   
 Wavelength  $\lambda = 6000 \text{ \AA}$

S.No.	Filament Current I Amp.	Filament voltage V volt	Corresponding $R_t/R_g$ from table or graph.	Photo-current $\mu\text{A}$	log $\theta$	T $^\circ\text{K}$ from graph $R_t/R_g$ Vs T $^\circ\text{K}$	$\frac{1}{T^\circ K} \times 10^{-4}$
1.							
2.							
3.							
4.							

**Calculations:**

From equation (7)

$$h = 2.303 \frac{\lambda_0 K}{c} \times \frac{\log \theta}{T^\circ K} \times 10^{-4}$$

Where  $\lambda_0 = 6000 \text{ \AA}$  mean wavelength of light

$k = 1.38 \times 10^{-16}$  erg/deg. Boltzmann's constant

$c = 3 \times 10^{10}$  meter/sec. velocity of light

$$\frac{\log \theta}{\frac{1}{T}} = \text{Slope of the curve.}$$

**Results:**

1..... The experimentally observed values of Planck's constant 'h' = .....erg/sec.

2. .... The standard value of Planck's

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constant

'h' =

The experimentally observed value of h is always within 10 to 15% of the standard value.

S. No.	Temperature (K)	R <sub>t</sub> /R
1	273	0.25
2	300	0.29
3	400	0.43
4	500	0.55
5	600	0.71
6	700	0.85
7	800	0.99
8	900	1.15
9	1000	1.29
10	1100	1.45
11	1200	1.61
12	1300	1.79
13	1400	1.95
14	1500	2.11
15	1600	2.3
16	1700	2.46
17	1800	2.65
18	1900	2.85
19	2000	3.05
20	2100	3.26
21	2200	3.46
22	2300	3.66
23	2400	3.85

**Table Relation Filament**

**-IV**

**between R<sub>t</sub>/R<sub>g</sub> and Temperature K for Tungsten**

## Physics Lab (BSP-103P)

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### Quiz with Answers:

Q1. What is the photocell method used for?

Ans: To determine Planck's constant, which relates the energy of photons to their frequency.

Q2. How does the photocell method work?

Ans: By measuring the photocurrent generated when light of varying frequencies falls on a photosensitive surface.

Q3. What is the basic principle behind this method?

Ans: It utilizes the photoelectric effect, where photons eject electrons from the photosensitive surface, generating a photocurrent.

Q4. What equipment is required for the experiment?

Ans: A photocell, a variable frequency light source, a voltage source, and an ammeter to measure the photocurrent.

Q5. How is Planck's constant calculated using the photocell data?

Ans: By plotting the photocurrent versus the frequency and finding the slope of the linear portion, which is  $h/e$ , then solving for  $h$

## LAB EXPERIMENT 8

### SOLAR CELL CHARACTERISTICS

**AIM:** To study the characteristics of Solar cell and find out the fill factor.

**OBJECT** To study the characteristics of solar cell, the following studies can be carried out.

1. Illumination Characteristics.
2. Current Voltage Characteristics.
3. Power Load Characteristics.
4. Area Characteristics.
5. Spectral Characteristics.

#### OPTIONAL

1. Distance Vs Open Circuit Voltage.
2. Distance Vs Short Circuit Current.
1. Measurement of Short Circuit Current ( $I_{ESC}$ ) with biasing the solar cell and compare it with the theoretical value obtained from current voltage characteristics curves.

#### **THEORY:**

Solar cells are basically solid-state devices. It is basically a p-n junction, which converts sunlight (solar energy) into electrical energy through a three-step process:

2. **Generation of carrier pairs (electron hole pairs)**
3. **Separation of electrons and holes**
4. **Collection of separated carriers**

The details of each of the three processes are beyond the scope of this manual. Pl see text books. When a solar cell is illuminated, the photons incidents on the cell generate electrons-hole pairs. By diffusion in the material the electron and holes reach the junction. At the junction the barrier field separates the positive and negative charges carriers. Under the action of the electric field, the electrons (minority carriers) from p region are swept into n region. Similarly, the holes from n region are swept into p region. It leads to an increase in the number of holes on the p side and of

## Physics Lab (BSP-103P)

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the electrons on the n side of the junction. The accumulation of charges on the two sides of the junction produces an emf, which is called a photo emf. The photo emf is known as open circuit voltage. It is proportional to the illumination ( $\text{mW}/\text{cm}^2$  or  $\text{lumen}/\text{cm}^2$ ) and on the size of the illuminated area. When an external circuit is connected across the solar cell terminals, the minority carriers return to their original sides through the external circuit, causing the current to flow through the circuit. Thus the solar cell behaves as a battery with n side as the negative terminal and p side as positive terminal. The photo emf or voltage can be measured with a voltmeter. The process of generation of photovoltaic voltage is shown in Fig.

(1) The conversion of optical energy is known as photovoltaic effect. Hence a solar cell is also called a photovoltaic cell.

All solar cell materials used till date are semiconductors in crystalline or amorphous forms. A common characteristic of these materials is that they possess a band gap i.e. a discontinuity or rather a range of forbidden values in the energy spectrum. Mostly, solar cells are fabricated from silicon single crystals; Silicon is not transparent for visible light. Therefore, the surface layer of the cell, which is of p type, is made extremely thin to enable maximum light to penetrate the junction. It is desired the absorption of light takes place at the junction region such that the generated electron holes pairs can be separated by the junction fields before they are lost by recombination. To enhance the transmission of the light into the material an anti-reflection coating is given over p type layer. Thin metallic films vacuum deposited suitably on both the sides of the cell act as electrodes. An open circuit voltage of peak value of 0.6 V is generated by a solar cell. Silicon wafer of 1" dia to 4" dia are used to fabricate solar cells. In order to enhance the total voltage and current output, a number of P-n junction are formed on a wafer, using a mesh type or finger like electrode structure. To increase power output, solar cells are arrayed into a series chain or parallel chain and are interconnected. Such an arrangement is called a solar panel. In normal use single solar cell is rarely used, as its output is very low.

### **(i) Illumination Characteristic**

The Illumination Characteristic of a solar cell is shown in the Fig. (2). It is seen that the current through the solar cell increases as the intensity of the light falling on the solar cell increases.

### **(ii) Current Voltage Characteristic**

The output characteristic (current voltage characteristics) of a solar cell is shown in the Fig. (3) it is seen that in the open circuit, the output voltage of the cell is  $\approx 0.6$  V and the current is zero. If the panel is short circuited, the current is maximum while the output voltage of the cell becomes zero. In both the cases, the output power is zero. It is seen from the curve that the voltage varies depending on the current drawn.

### **(iii) Power Load Characteristics**

To derive maximum power from the panel, an appropriate load is to be connected across it. The value of the load that allows the cell to give maximum output power is obtained by drawing a power load characteristics, as shown in the Fig. (4). It is seen that a load other than  $(R_L)_{\text{max}}$  will produce less power.

### **(iv) Area Characteristics:**

The power delivered is proportional to the surface area of the solar panel exposed to the light. It is governed by the relation,

$$P = K A$$



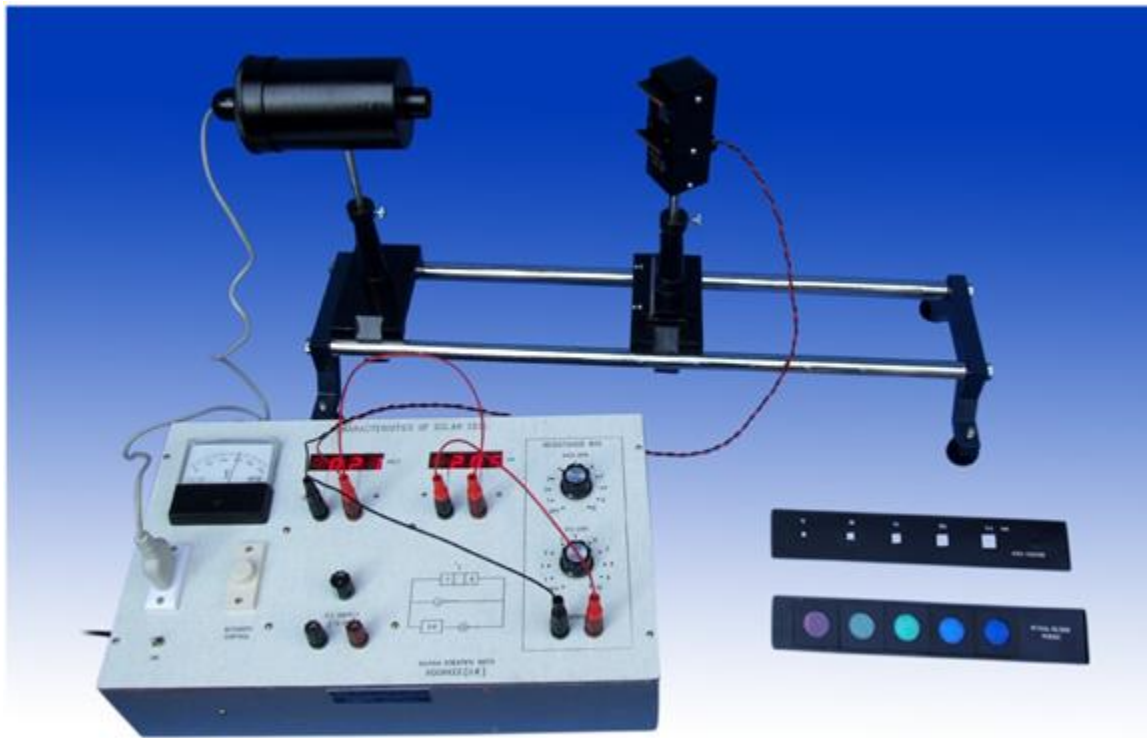
## Physics Lab (BSP-103P)

Where,  $P$  is the total power available  $A$  is the area of the Cell  
 $K$  is a constant.

The dependence of  $P$  on  $A$  is shown in the Fig. (5)

### (v) Spectral Characteristics:

The response of a solar cell to light depends on the wavelength of the incident light also. In the sunlight, different colors have different intensities. The variation of power on wavelength is shown in the Fig.(6)



## PROCEDURE

### (a) Illumination Characteristics

1. Make the circuit as shown in fig. 7. A 100 W lamp is arranged over the solar cell such that the light falls on it at normal. The intensity control is kept at its minimum say at 50 volts and the lamp is switched on.
2. Adjust the resistance box at zero ohm (i.e. both the knobs marked X10 and X100 ohm must be set at off position) note the short circuit current and make table as shown below.

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3. Increase the intensity of the lamp in steps say 100, 150, 200 volts and note the corresponding current for each setting of the voltage, record these readings in the table.

**Note:** Intensity is taken as proportional to the A.C. voltage given to the lamp

a. Plot a graph between Current and the Intensity.

**Table – 1**

S.No.	Intensity (volts)	Current (mA)
1.		
2.		
3.		

**(b) Current Voltage Characteristics**

1. The intensity of the lamp is kept at the minimum say 100 V. disconnect the load resistance (i.e. R.B. is at infinity) and note the open circuit voltage.

2. Adjust the resistance box (R.B.) at zero ohm (i.e. both the knob of the resistance box marked X10 and X100 ohm must be set at off position) and note the short circuit current.

3. Set the load dial at 100 ohms. Note the corresponding voltage and current make the table as shown below and record these readings in the table. Vary the load in steps up to 1100 ohms and note the corresponding voltage and current for each setting of the load in table

4. The intensity of the lamp is increased say 150 V. The load is again varied from 100 to 1100 ohms and note the corresponding voltage and the currents, record the value in the table. The open circuit voltage and the short circuit current are also determined and recorded.

5. The intensity of the lamp is set at 200 V, and repeat step 4. Record these readings in the table.

6. Plot a graph for Current Vs Voltage.

**Table – 2**

S.No.	R <sub>L</sub>	Intensity, I <sub>1</sub>		Intensity, I <sub>2</sub>		Intensity, I <sub>3</sub>	
	Ohms	Voltage (V)	Current (mA)	Voltage (V)	Current (mA)	Voltage (V)	Current (mA)

**(c) Power Load Characteristics**

Using the sets of the reading obtained in the table 2 above, calculate the output power of

## Physics Lab (BSP-103P)

the cell. Make table as shown below and record the readings in the table.

- Plot a graph for Power Vs Load. Measure the value of the optimum load that draws maximum power from the cell.

**Table – 3**

S.No.	R <sub>L</sub>	Intensity,	Intensity,	Intensity,
	Ohms	I <sub>1</sub> = 100 V	I <sub>2</sub> = 150 V	I <sub>3</sub> = 200 V
		Power mW	Power mW	Power mW
1	100			
2	200			
3	....			

**(d) Area Characteristics:**

- Set the intensity of the lamp at a convenient level say 200V. Adjust the load at the optimum value.
- Place the chopper plate having different slot areas, in front of the solar cell in the groove provided.
- Adjust one of the slot say 16 mm<sup>2</sup> over the solar cell; it reduces the surface area, which is illuminated. The voltage and the current readings are noted in the table. Note the corresponding voltage and current readings make table as shown below and record the readings in the table.
- Adjust the other slots say 36, 64, 100, 144 mm<sup>2</sup> over the solar cell and note the corresponding current and voltage for each slot area and record the readings in the table.
- Plot a graph for Power Vs Area. Measure the slope of the curve.

**Table – 4**

S . N o .	Slot Area mm <sup>2</sup>	Voltage, V volts	Current, I amp	Power P = VI mW
1				
2				
3				
4				
.				

**(e) Spectral Characteristics:**

- Set the intensity of the lamp to a convenient level say 200 V. Adjust the load at the optimum value.
- Put the different colors filter over the solar cell and for each filter the note voltage and the current and record these readings in the table.
- The wavelength corresponding to each color is noted and calculate the output power

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4. Plot a graph for Power Vs Wavelength.

**Table – 5**

S · N o ·	Filter Color s	Peak Wavelength Transmitted, A°	V o l t a g e , V o l t s	Cu r r e n t, I a m p	Power P = VI mW
1					
2					
3					

**OPTION-**

**Distance Vs Open Circuit Voltage:**

Repeat step 1 of the current voltage characteristics and vary the distance between the source and the photocell and note the open circuit voltage for each position of the cell from the source say at 15, 18, 21, 24, 27, 30 cm.

**Distance Vs Short Circuit Current:**

Repeat step 2 of the current voltage characteristics and vary the distance between the source and the photocell and note the short circuit current for each position of the cell from the source say at 15, 18, 21, 24, 27, 30 cm.

**Experimental Measurement of Short Circuit Current:**

Make the circuit as shown in the fig. 7(b) using  $R_2$  and the multimeter. Set the lamp voltage say at 100 volts. Adjust the supply voltage at 1.5 volts and vary  $R_2$  till the voltmeter V reads Zero voltage. In this position the cell and the battery try to send current through R.B. and when both currents are equal no current will pass through

R.B. and thus no voltage drop across it as measured by the voltmeter. In this case, the current obtained through multimeter gives the short circuit current. Repeat the experiment for different values of lamp voltage say 150, 200 volts and note the corresponding short circuit current. Make

## Physics Lab (BSP-103P)

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table as shown below:

**Table - 6**

S.No.	Lamp Voltage	Experimental value of Short circuit current $I_{ESC}$	Theoretical value of Short circuit current obtained from V-I characteristics curve.
1.			
2.			
3.			

Compare the Experimental value of Short Circuit Current  $I_{ESC}$  with the Theoretical value.

### Quiz with Answers:

Q1. What is the purpose of studying the characteristics of a solar cell?

Ans: To understand its behavior and performance under different conditions.

Q2. How is the fill factor of a solar cell defined?

Ans: The fill factor is the ratio of the maximum power output of the solar cell to the product of its open-circuit voltage and short-circuit current.

Q3. What information can be obtained from the characteristics of a solar cell?

Ans: The open-circuit voltage, short-circuit current, and power output at different operating points.

Q4. How are the characteristics of a solar cell typically plotted?

Ans: In a current-voltage (I-V) curve and a power-voltage (P-V) curve.

Q5. How is the fill factor calculated from the I-V curve?

Ans: By dividing the maximum power point on the curve by the product of open-circuit voltage and short-circuit current.

# Physics Lab (BSP-103P)

## LAB EXPERIMENT 9

### CALENDER AND GRIFFITH CHARACTERISTICS

**AIM:** To determine the temperature coefficient of resistance of platinum by means of Callendar and Griffith's pattern bridge.

**APPARATUS :** Platinum resistance thermometer, Callendar and Griffith's pattern bridge, a Leclanche cell, a galvanometer, beaker (600 c.c. capacity), electric stove, a decimal-ohm dial box, a mercury thermometer and connection wires.

**THEORY :** Callendar and Griffith's pattern bridge. For work at the undergraduate level such a piece of apparatus is manufactured. By Instrument & Chemicals Ltd. Ambala. The circuit diagram of the bridge is given in figure 1.

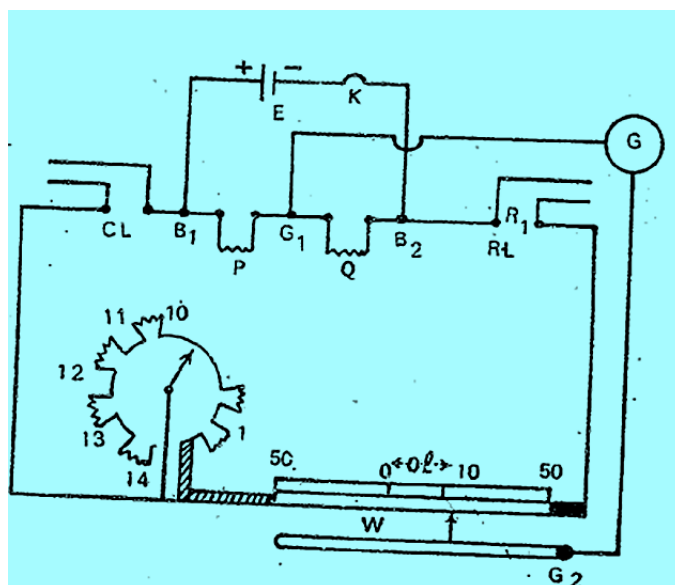


Figure 1

The ratio coils P and Q have equal resistance, so that the ratio is 1:1. CL and RL are the gaps for connecting the compensating and the resistance leads of the thermometer. R is a dial pattern resistance, each coil having a resistance of one ohm. In series with this is a stretched wire W, also of resistance one ohm. The scale for the reading of the length of the wire is graduated with zero in the middle and 50 division marks at either end. Thus the value  $\square$ , the resistance per unit length of the bridge wire is 1/100 ohms per unit length.

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Suppose with connections as shown in the figure above, the null point is at a length  $l$  measured from middle points of the wire. Let  $R_1$  be the required resistance of the platinum wire, say at room temperature  $t_1$  and  $R$  the resistance introduced in the dial box.

Then

$$\frac{P}{Q} = 1 - \frac{y + R + 50l}{y + R_1 + 50l}$$

Where  $\rho$  is the resistance per unit length of the bridge wire and  $y$  is the resistance of the leads. From the above equation we have

$$y + R_1 + 50l = y + R + 50l$$

$$R_1 = R + 2l \quad (a)$$

Where  $\rho$  is known,  $R_1$  can be calculated from the observed values of  $R$ .

Similarly, if  $R_2$  be the resistance of the platinum wire of the thermometer at a temperature  $t_2$ , then  $R_2$

$$= R + 2l \quad (b)$$

Knowing  $R_1$  and  $R_2$ ,  $\rho$  can be calculated from the relation.

$$\rho = \frac{R_2 - R_1}{R_2 t_2 - R_1 t_1}$$

### PROCEDURE :

#### (I) Determination of electrical Zero of the bridge.

Connect the Laclanche cell through a key  $K$  across the terminals  $B_1$  and  $B_2$  and the galvanometer across  $G_1, G_2$ . Put the dial box  $R$  at zero. Close the gaps  $CL$  and  $RL$  by thick copper strips.

Insert the plug of the key  $K$  of the cell circuit and determine the position of the null point by pressing the jockey in the neighborhood of the middle of the wire. Note this position. This gives the position of the electrical zero of the bridge wire. For an accurate bridge it should be at zero of the scale – this zero of the scale being at the middle point of the wire and 50 division marks on either side being at the ends of the wire. The difference between the zero of the scale and the electrical zero may be termed as the zero error of the bridge. Due correction must be applied in subsequent observations.

#### (II) Determination of $\rho$ , the resistance per unit length of the bridge wire.

Remove the copper strip from the gap  $CL$ . Connect a decimal ohm resistance box across  $CL$ . The dial box  $R$  stands at zero. Insert  $r$  of, say, 0.3 ohm in the gap  $CL$ , by rotating the dial of the

## Physics Lab (BSP-103P)

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decimal ohm box and locate the null point on the bridge wire. Measure the length from the zero of the scale. Correct this length for the zero error of the bridge by subtracting from this length the zero error of the bridge with its appropriate sign. Let this corrected length be  $L_1$  units.

Then evidently, since  $R = 0$ ,  $R = 0.3 = 2L_1 \square$

$$\text{Or } \square = \frac{r}{2L_1} = \frac{0.3}{2L_1} \text{ ohm per unit length}$$

Repeat the observations by introducing resistance of value 0.4, 0.5, 0.6 ohm from the decimal – ohm dial box across CL. Calculate  $\square$  from each set and find its mean value.

### (III) Determination of $R_1$ and $R_2$ .

Disconnect the decimal ohm dial box from the gap CL and the copper strip from the gap RL. Connect the compensation leads of the platinum resistance thermometer across CL and its resistance leads across RL.

Introduction a resistance of 2 ohms in the dial box R and locate the balance point on the bridge wire. (Usually the resistance of the thermometer lies between 2 and 3 ohms). Correct this length for the zero error of the bridge wire and knowing the values of R, L and  $\square$ , calculate  $R_1$  from equation a.

By changing the value of R to 3 ohms, redetermine the value of  $R_1$ . It may be noticed here that with R equal to 2 ohms, the balance point was on the positive side of the scale (i.e., on to the right of zero of the scale) whereas with R equal to three ohms, the balance point is obtained on the left hand side of the zero, i.e. on the negative side of the scale. In the latter case  $R_1$  will be calculated from the relation

$$R_1 = R - 2L\square$$

Find the mean value of  $R_1$ . Record the room temperature  $t_1$  °C. Thus the resistance  $R_1$  of the platinum coil is known at a temperature  $t_1$  °C.

Next place the platinum resistance thermometer in a large beaker or container with water. Allow the water to boil by heating the container over an electric stove. Also put a mercury thermometer to record the temperature  $t_2$  of boiling water.

When water in the container has been boiling for about ten minutes or so, introduce a resistance of 3 ohms in the dial, box R and locate the new balance point on the bridge wire, which will now be again on the positive side of scale. Repeat this observation after every two minutes, and when the reading does not change it can be assumed that the platinum coil has attained the temperature  $t_2$  °C of boiling water, as recorded by the mercury thermometer. Note this length for the balance point and correct it for zero error. From a knowledge of the resistance R (3 ohms), the corrected length  $l^1$  for



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balance and .... Calculate  $R_2$  from the equation (b)

Put R at 4 ohms and redetermine the value of  $R_2$ . Compute the mean value of  $R_2$  from those two determinations.

### SOURCE OF ERROR AND PRECAUTIONS

- 1) The decimal ohm box should be preferably of dial pattern and should be connected by short, thick wires.
- 2) The cell circuit should be made on by the plug key only when observations are being taken; for the rest of the time, the plug should be out of the key. This would prevent unnecessary heating of the resistance coils due to the passage of current.
- 3) The galvanometer should be shunted by a low resistance wire to avoid excessive deflections in it when the bridge is out of balance the shunt should be removed when the exact position of the null point is being determined.
- 4) The jockey should be pressed gently over the bridge wire; and the contact between the jockey and the bridge wire should not be made while the jockey is being moved along.
- 5) To ascertain that the platinum coil has attained the temperature of boiling water, the position of the balance point must be found out every minute or every two minutes; if there is no shift in the balance point it can be assumed that the platinum coil has attained the temperature of boiling water. If there is any shift, it should be of a negligible order, a mm. or so. The mean of such close lengths should be taken to obtain the length for balance of the bridge.

### CALCULATION FOR $R_1$ and $R_2$

Calculation for  $R_1$  and  $R_2$

From Set 1,  $R_1 = R + 2(l \pm Z)$  □

=

= ohm

From set 2,  $R_1 = R - 2(l \pm Z)$  □

=

= ohm

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Mean value of  $R_1 =$  ohm Similarly,

Mean value of  $R_2 =$  ohm

Hence

$$\frac{R_2 - R_1}{R_2 t_2 - R_1 t_1}$$

=

= per  $^{\circ}\text{C}$

### RESULT

The temperature coefficient of resistance for platinum = per  $^{\circ}\text{C}$ . Standard value of  $\alpha =$  per  $^{\circ}\text{C}$

Percentage error =

### Quiz with Answers:

Q1. What is the Callendar and Griffith's pattern bridge used for?

Ans: To determine the temperature coefficient of resistance (TCR) of platinum.

Q2. What is the temperature coefficient of resistance?

Ans: The rate of change of resistance per degree Celsius of temperature change.

Q3. How does the Callendar and Griffith's pattern bridge work?

Ans: It compares the resistance of the platinum element at different temperatures to find its TCR.

Q4. What are the components needed for the experiment?

Ans: A pattern bridge setup, a calibrated resistance, a platinum element, and a temperature-controlled environment.

Q5. How is the bridge balanced in the experiment?

Ans: By adjusting the known resistances until the bridge is in a state of null or zero deflection.

Q6. Why is platinum used in this experiment?

Ans: Platinum has a relatively stable TCR over a wide temperature range, making it suitable for accurate measurements.

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## LAB EXPERIMENT 10

### **P-N JUNCTION DIODE CHARACTERISTICS**

**AIM:** To study the forward and reverse characteristics of P-N junction diode.

1. To plot Volt-Ampere Characteristics of Silicon P-N Junction Diode.
2. To find cut-in Voltage for Silicon P-N Junction diode.
3. To find static and dynamic resistances in both forward and reverse biased conditions for Si P-N Junction diode.

Name	Qty
Diodes IN 4007(Si)	1
Resistor 1K $\Omega$ , 10K $\Omega$	1

Name	Range	Qty
Bread Board	-	1
Regulated Power Supply	0-30V DC	1
Digital Ammeter	0-200 $\mu$ A/20mA	1
Digital Voltmeter	0-2V/20V DC	1
Connecting Wires		

### **Components and Equipment's:**

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### Theory:

Donor impurities (pentavalent) are introduced into one-side and acceptor impurities into the other side of a single crystal of an intrinsic semiconductor to form a p-n diode with a Junction called depletion region (this region is depleted off the charge carriers). This region gives rise to a potential barrier  $V$  called ***Cut- in Voltage***. This is the voltage across the diode at which it starts conducting. It can conduct beyond this Potential.

The P-N junction supports uni-directional current flow. If +ve terminal of the input supply is connected to anode (P-side) and –ve terminal of the input supply is connected to cathode (N- side) then diode is said to be forward biased. In this condition the height of the potential barrier at the junction is lowered by an amount equal to given forward biasing voltage. Both the holes from p-side and electrons from n-side cross the junction simultaneously and constitute a forward current (***injected minority current*** – due to holes crossing the junction and entering N-side of the diode, due to electrons crossing the junction and entering P-side of the diode). Assuming current flowing through the diode to be very large, the diode can be approximated as short-circuited switch.

If –ve terminal of the input supply is connected to anode (p-side) and +ve terminal of the input supply is connected to cathode (n-side) then the diode is said to be reverse biased. In this condition an amount equal to reverse biasing voltage increases the height of the potential barrier at the junction. Both the holes on p-side and electrons on n-side tend to move away from the junction thereby increasing the depleted region. However the process cannot continue indefinitely, thus a small current called ***reverse saturation current*** continues to flow in the diode. This small current is due to thermally generated carriers. Assuming current flowing through the diode to be negligible, the diode can be approximated as an open circuited switch.

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### Circuit Diagram

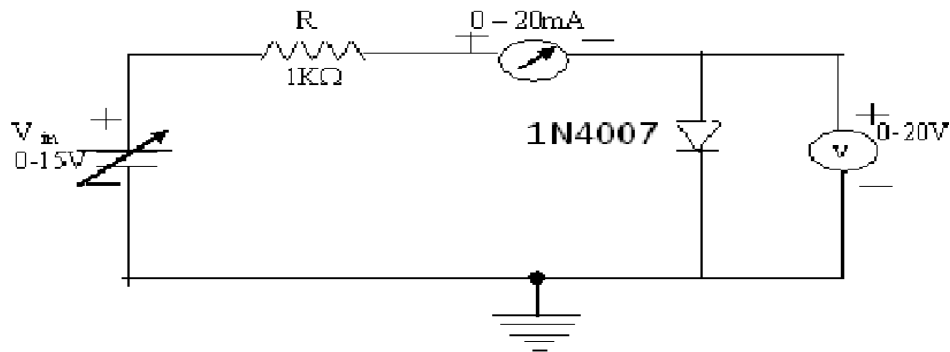
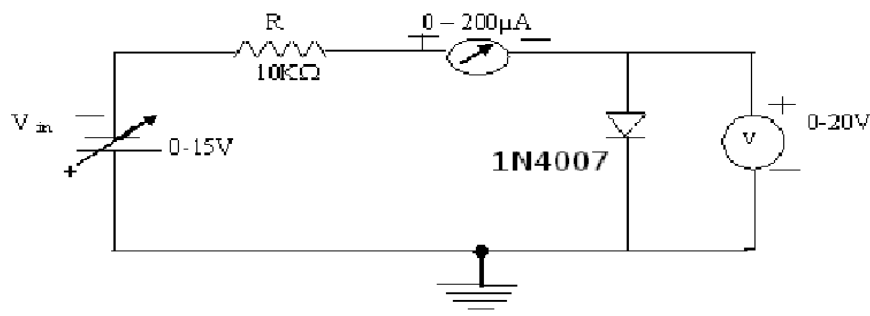


Fig (2) - Reverse Biased condition:



### **Procedure:**

#### **Forward Biased Condition:**

1. Connect the circuit as shown in figure (1) using silicon PN Junction diode.
2. Vary  $V_f$  gradually in steps of 0.1 volts upto 5volts and note down the corresponding readings of  $I_f$ .
3. Step Size is not fixed because of nonlinear curve and vary the X-axis variable (i.e. if output variation is more, decrease input step size and vice versa).
4. Tabulate different forward currents obtained for different forward voltages.

#### **Reverse biased condition:**

1. Connect the circuit as shown in figure (2) using silicon PN Junction diode.
2. Vary  $V_r$  gradually in steps of 0.5 volts upto 8 volts and note down the corresponding readings of  $I_r$ .
3. Tabulate different reverse currents obtained for different reverse voltages. ( $I_r = V_R / R$ , where  $V_R$  is the voltage across  $10K\Omega$  resistor)

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### Observations

Si diode in forward biased conditions:

Sl. No	RPS Voltage	Forward Voltage across the diode $V_f$ (volts)	Forward current through the diode $I_f$ (mA)

Si diode in reverse biased conditions:

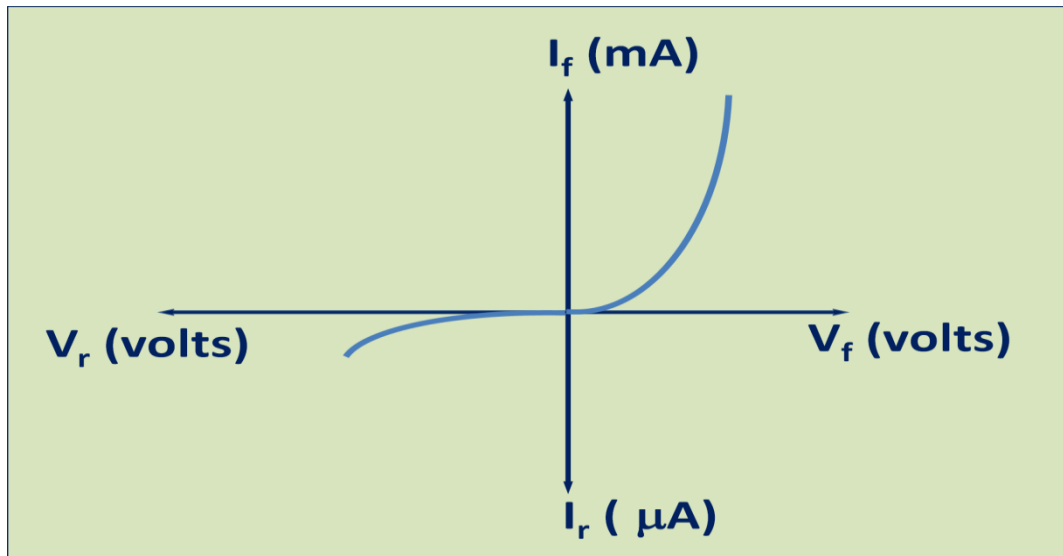
Sl. No	RPS Voltage	Reverse Voltage across the diode $V_r$ (volts)	Reverse current through the diode $I_r$ ( $\mu$ A)

### Graph (Instructions):

1. Take a graph sheet and divide it into 4 equal parts. Mark origin at the center of the graph sheet.
2. Now mark + ve x-axis as  $V_f$ 
  - Ve x-axis as  $V_r$
  - + Ve y-axis as  $I_f$
  - ve y-axis as  $I_r$ .
3. Mark the readings tabulated for Si forward biased condition in first Quadrant and Si reverse biased condition in third Quadrant.

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### Calculations from Graph:



Static forward Resistance  $R_{dc} = V_f / I_f \Omega$  Dynamic forward Resistance  $r_{ac} = \Delta V_f / \Delta I_f \Omega$

Static Reverse Resistance  $R_{dc} = V_r / I_r \Omega$

Dynamic Reverse Resistance  $r_{ac} = \Delta V_r / \Delta I_r \Omega$

### Precautions:

1. While doing the experiment do not exceed the ratings of the diode. This may lead to damage the diode.
2. Connect voltmeter and Ammeter in correct polarities as shown in the circuit diagram.
3. Do not switch **ON** the power supply unless you have checked the circuit connections as per the circuit diagram.

### Result:

1. Cut in voltage = ..... V
2. Static forward resistance = .....  $\Omega$
3. Dynamic forward resistance = .....  $\Omega$

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### Quiz with Answers:

Q1. What is the purpose of studying the forward and reverse characteristics of a P-N junction diode?

Ans: To understand how the diode behaves under different biasing conditions.

Q2. What is a P-N junction diode?

Ans: A semiconductor device formed by joining P-type and N-type semiconductor materials.

Q3. How is the diode biased in the forward direction?

Ans: By applying a positive voltage to the P-region and a negative voltage to the N-region.

Q4. What happens to the diode in the forward bias condition?

Ans: It allows current to flow easily, exhibiting low resistance, and conducts electricity.

Q5. What is the forward voltage drop of a P-N junction diode?

Ans: It is typically around 0.7 volts for silicon diodes and 0.3 volts for germanium diodes.



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Crosschecked

By

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Please spare some time to provide your valuable feedback.

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