Department of Applied Physics

Experiment No. : ----------------- Date of Performance : -----------------

Name of the Student : ---

Division : -------------- Roll No. :-----------------

Newton's Rings

Aim :

To determine the radius of curvature of a planoconvex lens by using Newton's rings. (OR To determine the wavelength of incident light)

Apparatus :

A traveling microscope with long focus objective, Newton's rings apparatus, sodium lamp, magnifying glass, reading lamp etc.

Ray Diagram :

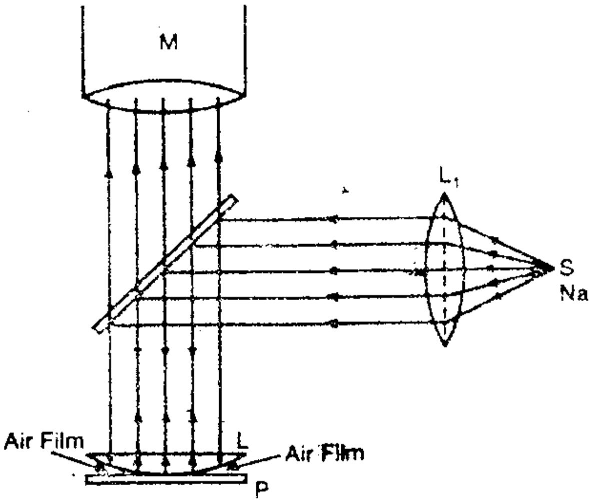


Fig.

Formula :

$$R = \frac{Slope}{4\lambda} \quad OR \quad \lambda = \frac{Slope}{4R}$$

where,

$$Slope = \frac{Dn^2 - Dm^2}{(n-m)} \qquad n > m$$

R = radius of curvature of planoconvex lens

λ = wavelength of sodium light ($5893A^0$)

Procedure:-

1) Arrange the apparatus as shown in the Fig. Clean the lens and glass plate thoroughly and then place the planoconvex lens on the glass plate. With its convex surface touching the plate, place it below the microscope.
2) Allow the parallel light from sodium lamp to be incident on a glass plate, which is held at 45 degrees to the horizontal so that the reflected light falls upon the lens. Adjust the position of the microscope so that the point of contact is just below the microscope objective. Focus the microscope until the rings are distinctly visible and the center of ring system lies below the point of intersection at the cross wires. Rotate the eyepiece so that one of the cross wires is perpendicular to the horizontal scale.
3) Move the microscope across the field of vision and focus it on a distinct dark ring, say 20^{th} dark ring from the center on the left. Read the position of the microscope with the cross wire tangential to the ring. Focus on successive dark rings in steps of 05 and note the corresponding positions of the microscope. Continue this till you reach dark ring number 05. While focusing take care that every time the cross wire remains tangential to the ring.
4) Move the microscope across the center until it is focused at the other end of the diameter of the dark ring number 05. Read the position of the microscope and proceed onwards until you reach 20^{th} dark ring on the right. From the set of readings, diameters D_n of the rings can be determined.
5) Calculate D_n^2 and plot a graph of D_n^2 Versus ring number n. Calculate the slope of the straight line and knowing the wavelength of sodium light, calculate the radius of curvature of the planoconvex lens using the given formula.

Observations :

L.C. of traveling microscope = ………… mm

Observation Table:

Observation No.	No. of dark rings (n)	Microscope reading (cm)		Diameter (cm) $D_n = x_1 - x_2$	D_n^2 (cm^2)
		Left (x_1)	Right (x_2)		
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					

Nature of Graph :

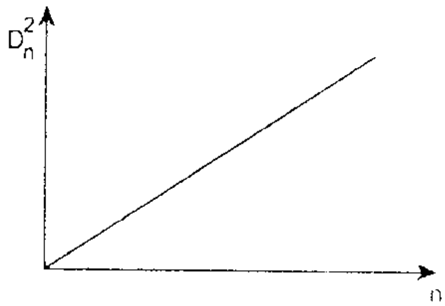


Fig.

Calculations:

$$R = \frac{Slope}{4\lambda} \qquad OR \qquad \lambda = \frac{Slope}{4R}$$

Result :

Radius of curvature of the planoconvex lens is ………. cm.

Wavelength of the source is …………..

Theory :

When a planoconvex lens is placed over a glass plate, a thin wedge shaped film is formed between the two glass surfaces. When illuminated by a beam of monochromatic light, interference takes place between the rays reflected from the lower surface of the lens and the upper surface of the glass plate (i.e., top and bottom surfaces of the air film). The interference pattern is in the form of circular fringes. The fringes are the locus of points of constant thickness of the air film.

The surfaces of the lens and the glass plate should be perfectly clean. The glass plate on which the lens is placed should be optically flat and the curved surface of the planoconvex lens must be perfectly spherical, in order to be able to observe the circular rings. Otherwise the fringes are irregular in shape. Newton's rings pattern when observed in the reflected light has a dark center. This is because at this position the lens and the plane glass plate touch each other and the thickness of the air film is zero. In the reflected light, the wave getting reflected at the surface of the denser medium has an additional phase shift of π radians, and hence the path difference corresponding to zero thickness is always $\frac{\lambda}{2}$.

In case some dust particles are present on the surfaces, the two surfaces do not have a perfect contact at the center leading to a bright spot at the center of the pattern. If both the surfaces are cleaned and rearranged we get a dark-spot.

The concentric alternated dark and bright rings in the Newton's rings pattern are numbered according to the following convention. The central dark spot in the pattern is called the 'zeroth dark ring.' This is followed by the 'first bright ring', which in turn is followed by the 'first dark ring'. The next ring is bright and is the 'second bright ring'. Then comes the 'second dark ring', and so on.

By theory, we know that the radii of dark rings are proportional to the square root of even natural numbers, whereas those of the bright rings are proportional to the square root of odd natural numbers. This fact is made use of in the present experiment.

Questions :

1) What are the requirements to get circular rings ?
2) Newton's rings pattern when observed in reflected light has a dark spot at center. Why ?
3) If we introduce a liquid (may be water or glycerin), between the planoconvex lens and plane glass plate, what will happen ?

4) If we use white light source instead of monochromatic light, can we get coloured rings ? Explain the nature of rings.
5) How will you change the thickness of the Newton’s rings pattern? Explain.

Department of Applied Physics

Experiment No. : ------------------ Date of Performance : ------------------

Name of the Student : --

Division : --------------- Roll No. :------------------

Diffraction Grating

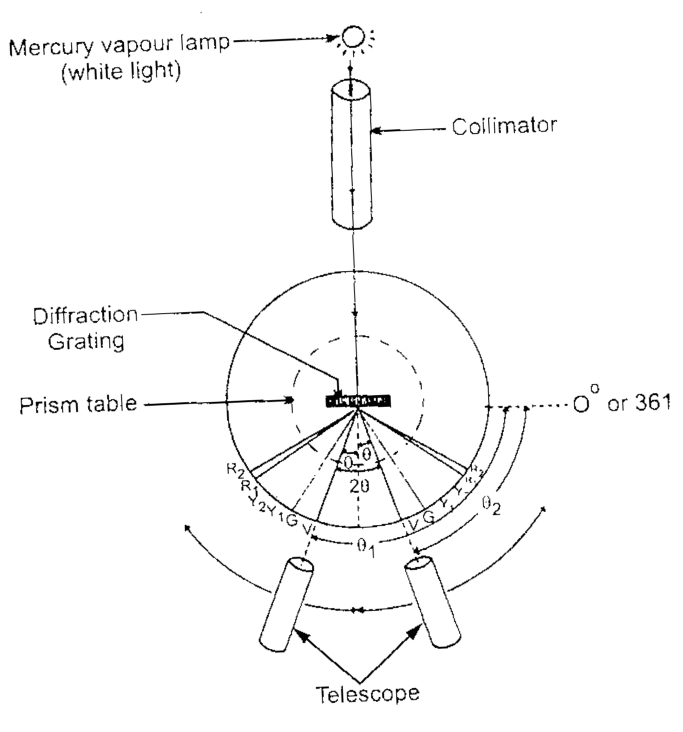
Aim :

To determine the wavelength of unknown light source using plane diffraction grating.

Apparatus :

Spectrometer, source of light (mercury lamp), diffraction grating, magnifying glasses, etc.

Ray Diagram: :



Formula :

$$(a + b) \sin\theta = n\lambda$$

where, (a + b) = grating element

a = width of a slit

b = distance between two adjacent slits

n = order of the spectrum

$$\% \, error = \frac{\lambda_{\exp} - \lambda_{std}}{\lambda_{std}} x100$$

where, λ_{exp} = experimental value of wavelength

λ_{std} = standard value of wavelength

Procedure :

1) Adjust the telescope and collimator for parallel rays by Schuster's method.
2) Mount the diffraction grating on the prism table such that its plane is perpendicular to the prism table.
3) Arrange the face of the grating so that it lies normal to the collimator.
4) Focus the vertical cross-wire of the eye-piece perfectly on the first (violet) line of the first order spectrum of left side. This focusing must be perfect for accurate results.
5) Clamp the telescope and note its angular position using the angular scale through the observation window. Use a reading lamp and magnifying glass to note the reading.
6) Similarly, take readings for the other lines of spectrum. These readings are θ_1.
7) Turn the telescope to the right side and take the readings for the first order spectrum on this side. These readings are $\theta_{2.}$
8) Calculate 2θ, θ, sinθ and therefore λ for each colour by using the given formula.
9) Compare your results (experimentally calculated wavelengths) with standard values and calculate how much the results deviated from standard ones by using the formula for percentage error.

Observations :

i) Grating element (a + b) = $\frac{2.54}{15000}$ = ……..…cm

= ……… x 10^8 A^0

ii) Least count of spectrometer = …………..

Observation Table:

Spectral lines	Angular Positions		$2\theta = \theta_1 - \theta_2$ (Deg min)	θ = 2θ / 2 (Deg min)	Sinθ	λ_{exp} = (a + b) sinθ A^0	λ_{std} A^0	% error
	Left θ_1 (Deg min)	Right θ_2 (Deg min)						
Violet							4387	
Green							5460	
Yellow							5790	
Red							6390	

Note: - Angle θ should be taken with + sign (-ve sign ignored) but in case of % error sign should be kept unchanged

Calculations:

Results :

1) Wavelength of Violet colour = ……….. A^0
2) Wavelength of Green colour = ……….. A^0
3) Wavelength of Yellow colour = ……….. A^0
4) Wavelength of Red colour = ……….. A^0

Theory :

Spectroscopy is a powerful research technique in Physics. It is useful for production, observation,analysis and interpretation of the spectra of given sources. The properties of a spectral source can be studied by calculating parameters like intensity, line width and wavelengths of the spectral lines.

Spectroscopy has been found applicable in determination of atomic and molecular structures and energy levels, study of interatomic and intermolecular interactions, identification of elements, identification of chemical compositions of unknown substances and their physical properties, etc. Verification of Bhor's model of the atom has been made possible due to spectroscopic analysis.

Spectroscopy is also an important research tool in Astrophysics where it is used for studying the compositions of planets and stars, their atmosphere, as well as their physical properties like pressure, density, temperature, etc. The fact that the sun is composed of 65 % helium and 35 % hydrogen has been discovered using spectroscopic analysis.

The aim of the experiment is one of the basic tasks in spectroscopy i.e. determination of wavelength of spectral lines. The distribution of dispersed radiated energy arranged periodically according to certain parameters like energy, frequency, wavelength, etc. is called the spectrum. The source can be made to emit the radiation by suitably exciting it by direct or electrical heating. The excited atoms re-emit the absorbed energy while returning to the ground state. This radiated energy can be converted into a spectrum using the spectrometer which is an instrument used to produce, observe and analyze the spectrum of a given source. It consists mainly of a collimator, a spectroscopic device, and a telescope.

The bending of any kind of wave when encountered by any obstacle of dimensioncomparable to its wavelength is called diffraction. A diffraction grating consists of a large number of exactly parallel and equidistant slits. The grating diffracts the light waves of various wavelengths emitted by the source through different angles, thereby making it possible to determine the wavelengths. Gratings are often used to measure wavelengths and to study the intensity of spectral lines.

Using mathematical analysis, it can be shown that the principal maxima of order 'n' for a given grating lies at an angle 'θ' which satisfies the following condition :

$(a + b) \sin\theta = n.\lambda$ where, $(a + b)$ = grating element

a = width of a slit

b = distance between two adjacent slits

n = order of the spectrum

The source used in this experiment is a mercury vapour lamp, which is a source of white light. It contains vapours of mercury in which electric discharge is produced by applying high voltage. The mercury spectrum consists of a few lines in the ultraviolet region and a few lines in the visible region.

Questions :

1. What is meant by diffraction of light?
2. Distinguish between Fresnel and Fraunhoffer diffraction of light waves.
3. What do you mean by diffraction grating element ?
4. Why we observe only four colours in the diffraction pattern with our available source?
5. Which are the natural examples of diffraction grating?

Department of Applied Physics

Experiment No. : ------------------ Date of Performance : ------------------

Name of the Student : --

Division : --------------- Roll No. :------------------

Law of Malus

Aim :

To verify cosine square law of Malus for plane polarized light using photo-voltaic cell.

Apparatus:

Photo-voltaic cell, moving coil galvanometer, lamp and scale arrangement, source of light, convex lens and two Polaroids.

Diagram :

Experimental arrangement

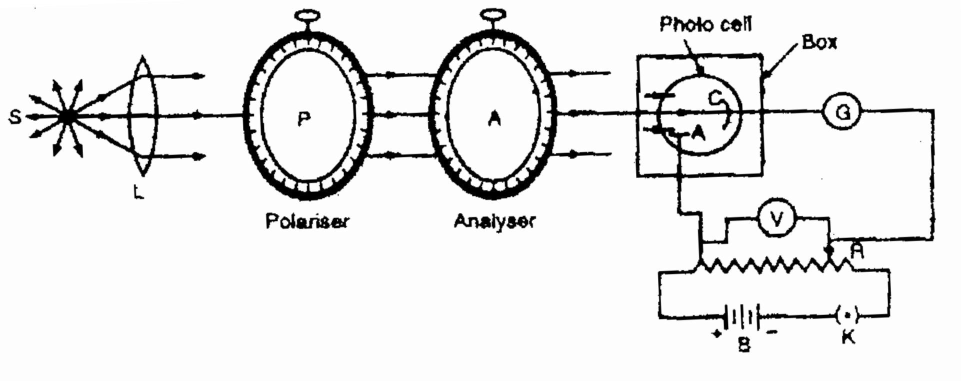


Fig.

Formula :

$$I = I_0 . \cos^2\phi$$

Where I_0 = Intensity of plane polarized light incident on the analyzer

ϕ = Angle between planes of transmission of polariser and analyzer

I = Intensity of the emergent light

Procedure :

1) Adjust all the apparatus as shown in the experimental arrangement (see the figure) and keep all the source, convex lens, polariser P, analyzer A and window of photo-voltaic cell at same height.

2) Adjust lamp and scale arrangement in such a way that the spot of light would be at zero of the scale.

3) Then open window of photo-voltaic cell and for any position of polariser P, rotate analyzer A till to get maximum deflection in the galvanometer.

4) Then record the position of analyzer on the circular scale and at the same time, the corresponding galvanometer deflection should be recorded. This position of analyzer may correspond to $\phi = 0^0$.

5) Rotate analyzer through a small angle say 10^0, and note steady galvanometer deflection on the scale.

6) Repeat experiment by rotating analyzer through 10^0 each time and note the corresponding deflection till it becomes practically zero.

Observation Table :

Sr. No.	Angle through whic analyzer is rotated ϕ	Steady galvanometer deflection I	cos ϕ	$\cos^2\phi$	$\frac{I}{\cos^2\phi}$
1					
2					
3					
4					
5					
6					
7					
8					

Graph :

Draw a graph between $\cos^2\phi$ on x-axis and θ on y-axis.

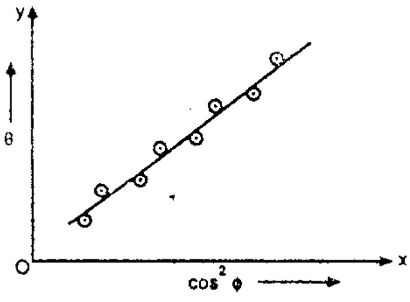


Fig.

The graph verifies the cosine square law (Malus Law).

Calculations :

Find the value of $\frac{I}{\cos^2 \phi}$ from each observation.

Department of Applied Physics

Experiment No. : ------------------ Date of Performance : ------------------

Name of the Student : ---

Division : --------------- Roll No. :------------------

Brewster's Law

Aim :

To determine Brewster's angle for a glass surface and hence to determine refractive index of glass.

Apparatus :

Spectrometer, monochromatic source of light, glass prism and polarized attachment to telescope objective.

Diagram :

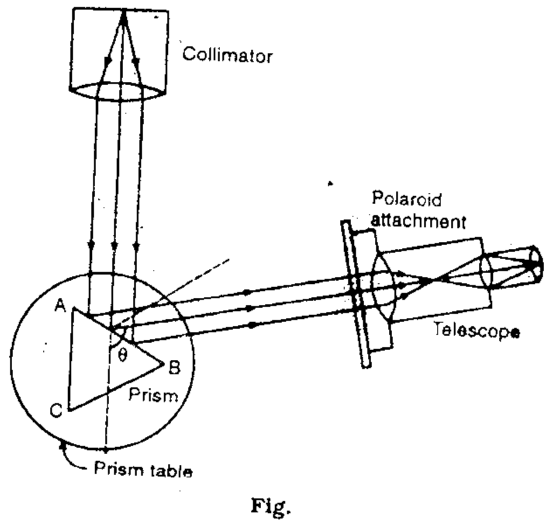


Fig.

Formula :

According to Brewster's law

$$\mu = \tan P$$

where μ = Refractive index of the material of prism

P = Angle of polarization

Observation :

Least count of vernier = ……… sec

Observation Table :

Sr. No.	Vernier used	Telescope reading for complete extinction of reflection image			Telescope reading for direct image			Difference (a – b)	Mean of column	Mean Θ
(1)	(2)	(3)			(4)			(5)	(6)	(7)
		Main scale reading	Vernier scale reading	Total reading (a) deg	Main scale reading	Vernier scale reading	Total reading (b) deg			
1	**V_1** **V_1**									
2	**V_1** **V_1**									
3	**V_1** **V_1**									

Calculations :

i) Polarizing angle, P = $(90 - \theta /2)$

ii) R.I. $\mu = \tan P$

Procedure :

1) First of all by removing the Polaroid attachment from the telescope, adjust spectrometer for experiment.
2) Place the prism on the prism table and mount the Polaroid attachment on the telescope objective.
3) Turn the telescope in such a way that the light reflected from one of the polished face of the prism is received in the telescope.
4) Then adjust telescope to obtain the reflected light on the cross wire.
5) Then rotate Polaroid slowly through one complete cycle and observe the variation of intensity of reflected light. The intensity may or may not be zero

   in a particular position of Polaroid. Let the intensity is not zero in one complete rotation of Polaroid.
6) Repeat step (4) and (5) to a number of times by increasing the angle of incidence – till reflected light shows zero intensity.
7) Record the position of the telescope and note readings of two verniers.
8) Then remove prism from the prim-table and turn telescope to get direct image of the slit.
9) Adjust the image of slit on the cross wire of the telescope and note readings of two verniers.
10) Determine the difference of the positions of telescope (i.e. angle θ)
11) Repeat experiment 3 to 4 times and find mean θ.

Result :

1) Polarizing angle, P = ……..
2) R.I. for material of the prism, μ = ……..

Precautions :

1) Prism surface must be very clean.
2) Near polarizing angle, the angle of incidence should vary slowly and carefully.
3) The test for complete extinction of reflected light should be done carefully.

Theory :

When a beam of ordinary light is incident at particular angle about 57^0 on a glass plate, the reflected light is plane polarized. Plane polarized light means that the light vector in the reflected light is vibrating transversely to the direction of transmission, in a fixed plane through this direction. At angles other than 57^0, the reflected beam is not completely plane polarized. It will consist vibrations parallel to the plane of the incidence as well as those perpendicular to the plane of incidence and falls to zero at angle θp (polarizing angle, about 57^0).

Brewster observed that for a particular angle of incidence, known as angle of polarization, the reflected light is completely polarized in the plane of incidence, i.e. having plane of vibration perpendicular to the plane of incidence.

Brewster proved that the tangent of the angle of polarization (P) is numerically equal to the refractive index (μ) of the medium, i.e. μ = tan P. This is known as Brewster's law. He also proved that the reflected and refracted rays are perpendicular to each other.

* * *

Questions :

1) What is the polarization of light ?
2) In Brewster's law by which method – the plane polarized light is produced ?
3) Is polarizing angle constant for all the materials ? Why ?
4) In engineering application, where this Brewster's law is used ?
5) What is polarization state of refracted and reflected light ?

Department of Applied Physics

Experiment No. : ------------------ Date of Performance : ------------------

Name of the Student : ---

Division : --------------- Roll No. :------------------

Laser

Aim : To find number of lines/cm of given grating using laser source

Apparatus : Laser Source, Grating Element, Scale and Screen, etc

Formula :

$$(a+b)\sin\theta = n\lambda$$

$$(a+b) = \frac{n\lambda}{\sin\theta}$$

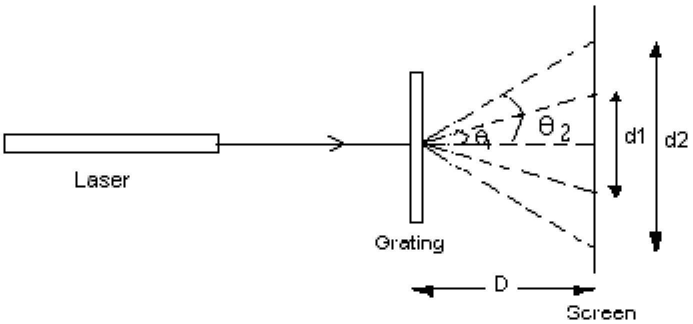
where, (a+b) =grating element (no of lines/cm)

a = width of a slit

b = distance between two adjacent slits

n = order of the spectrum

Diagram :



Observation table :

1) Wave length of laser source $\lambda =$ ____________ cm
2) Least Count of Scale $= 1mm = 0.1cm$
3) Distance between Grating and Screen **D**= ---------------- cm

4) Distance between First Order Diffracted Images $\mathbf{d_1}$ = --------------cm

5) Distance between Second Order Diffracted Images $\mathbf{d_2}$ = --------------cm

Calculations :

a. Calculation of θ

$$\theta_1 = \tan^{-1}\left(\frac{d_1/2}{D}\right)$$

$$\theta_2 = \tan^{-1}\left(\frac{d_2/2}{D}\right)$$

b. $(a+b) = \dfrac{n\lambda}{\sin\theta}$

c. For first order n=1 so $(a+b) = \dfrac{\lambda}{\sin\theta_1}$

d. For first order n=2 so $(a+b) = \dfrac{2\lambda}{\sin\theta_2}$

Result :

No. of lines/cm of given grating = $\dfrac{1}{a+b}$ = ------------------------

Questions :

1) What are the properties of laser ?
2) Explain the following terms :

i) Spontaneous emission ii) Stimulated emission iii) Population inversion.

3) Explain action of gas laser. How does stimulated emission take place with exchange of energy between Helium and neon atoms ?

4) Explain the operation of He - Ne laser.

5) Define and explain the terms :

i) Pumping ii) Active systems.

Department of Applied Physics

Experiment No. : ------------------ Date of Performance : ------------------

Name of the Student : --

Division : --------------- Roll No. :------------------

Ultrasonic Interferometer

Aim :

To determine the speed of ultrasonic waves in a given liquid medium and hence determine its compressibility using ultrasonic interferometer.

Apparatus :

Ultrasonic interferometer, liquid (distilled water), high frequency generator, Co-axial shielded cable to connect high frequency generator to the measuring cell of the interferometer.

Schematic Diagram :

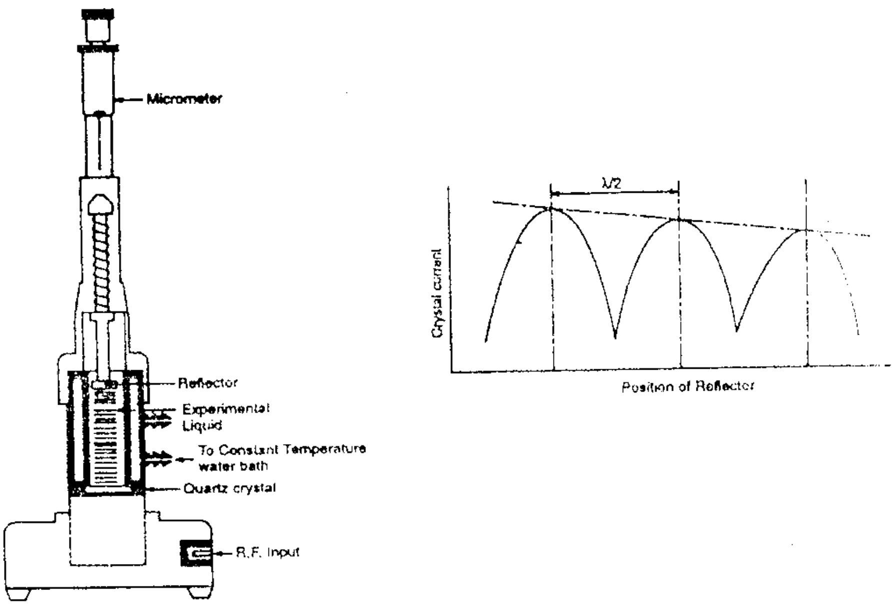


Fig. : Position of Reflector

Formula

$\beta = 1/(\rho v^2)$ *and* $v = f \cdot \lambda$

where, β = compressibility of a liquid

ρ = density of liquid

v = speed of ultrasonic waves in medium

f = frequency of wave

λ = wavelength of wave = $2\,\frac{d}{n}$

d = distance of the reflector plate from the quartz crystal plate

n = number of deflections in the ammeter when the reflector plate moves through the distance d

Procedure :

1) Insert the cell in the circular base socket and clamp it with the help of the screw provided on one of its sides.
2) Unscrew the curled cap of the cell and lift it away from the double wall. Pour the liquid in the screw on the cap. The scale should be in front of observer.
3) Connect the high frequency generator to the measuring cell using the cable provided.
4) For the initial adjustment, two knobs are provided on the high frequency generator, one is marked (Adj) and the other is marked (Gain).
5) Switch on high frequency generator and wait for 15 sec to warm it up. Initially, the needle of the ammeter goes to maximum, indicating that the ultrasonic waves are produced.
6) Adjust the needle to the neutral position (at 50 A) using adj knob. Keep the sensitivity (using the gain knob) such that the needle goes to 60 A.
7) Keep the micrometer on exactly 10 mm.
8) Keep the micrometer screw moving slowly so that the reflector plate is moved upwards. Carefully observe the ammeter scale. Whenever the condition $d = \frac{n\lambda}{2}$ is satisfied, the current will peak and the ammeter will show maximum deflection of the needle. Immediately stop at this stage and note the reading on the scale. This is the first reading.
9) Continue rotating the micrometer screw. Every time the instrument satisfies the above condition, the ammeter needle will show maximum deflection. Continue rotating the screw while counting the number n of deflections. Stop immediately after the chosen value of n and note down the micrometer reading.

10) Calculate the speed of ultrasonic waves using the given formula.

Observations :

1) Liquid used = distilled water
2) Density of liquid =
3) Frequency applied = 2 x 10^6 Hz
4) Least count of micrometer = ……… cm

Observation Table :

Observation No.	No. of deflections (n)	Micrometer reading d_1 (cm)	Micrometer reading d_2 (cm)	$d = d_1 - d_2$ (cm)	$\lambda = \frac{2d}{n}$ (cm)	$v = f \cdot \lambda$ (cm / s)
1.	**0-05**					
2.	**05-10**					
3.	**10-15**					
4.	**15-20**					
5.	**20-25**					
6.	**20-30**					

Result :

The speed of ultrasonic waves in the given liquid is ………… m/s.

Theory :

An ultrasonic interferometer offers a direct method of determining the speed of ultrasonic wave in liquids. The measurement is based on accurate determination of the wavelength in the given medium.

Ultrasonic waves of known frequency are produced by a quartz crystal, which is fixed at the bottom of the cell. These waves are reflected by a movable metallic plate, which is kept parallel to the quartz crystal. If the separation between these two plates is exactly a whole multiple of the wavelength, standing waves are formed in the medium. This creates an electrical reaction in the generator, which drives the quartz crystal. As a result, the anode current of the generator becomes maximum. If the distance is increased or decreased by $\frac{\lambda}{2}$ or a multiple of it, the anode current becomes maximum. The velocity of ultrasonic wave can be calculated from the knowledge of the wavelength.

Questions :

1) What are ultrasonic waves ?
2) Explain the principle of the experiment.
3) How standing waves are generated in the measuring cell ?
4) Can we use this method for dense liquid such as Castor oil ?
5) What is the condition to get maximum current in the meter ? Explain in brief.

Department of Applied Physics

Experiment No. : ------------------ Date of Performance : ------------------

Name of the Student : --

Division : --------------- Roll No. :------------------

Energy gap of semiconductor

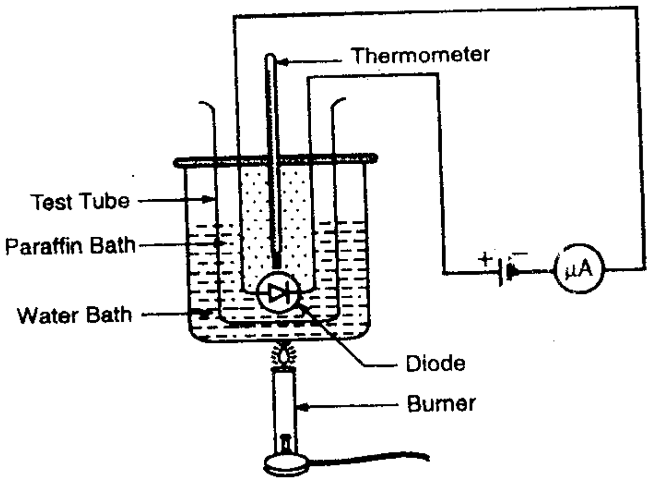
Aim :

To determine the forbidden energy gap of a semiconductor.

Apparatus :

P-N diode, water or oil bath, thermometer, 0-50 μA ammeter, 1.5 V cell, heating coil, etc.

Circuit Diagram :



Formula :

$$E_g = 2 . k . \beta$$

Where, k = Boltzmann's constant = 1.37×10^{-23} JK^{-1}

β = Slope of graph of $\ln R_T$ Vs $1/T$

E_g = Energy gap

Procedure :

1) Measure voltage of a given cell or battery.
2) Connect the circuit as shown in the diagram and get it checked by teacher.
3) Measure the normal temperature and corresponding leakage current.

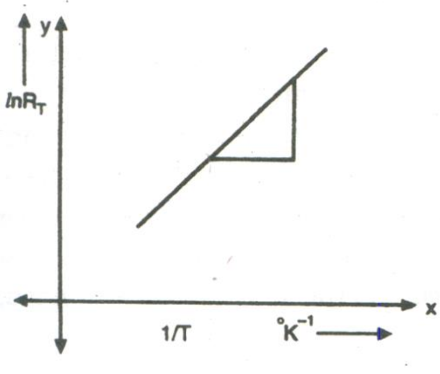
4) Start heating the water or oil bath using heater or burner.
5) Measure current at 35^0C and then upto 75^0C, in steps of 5^0C each.
6) Alternatively, heat the diode upto 75^0C, turn off the heater and measure the current as the diode cools down to 35^0C, in steps of 5^0C each.
7) Calculate R_T, $\ln R_T$ and 1/T.
8) Plot a graph of $\ln R_T$ Vs 1/T and find the slope of graph, as β.
9) Substitute β in the given formula to find 'E_g' in joules and then in electron volt.
10) Compare it with the standard value for given diode.
11) Also plot graph of R Vs T, to verify that R falls non-linearly with increase in temperature.

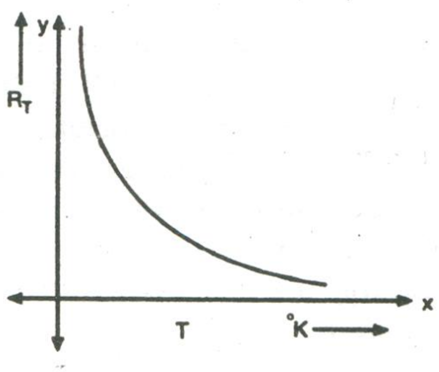
Observation Table :

Battery voltage (V) = ……………… volts

Sr. No.	Temperature t^0C	I (μA)	T = (t + 273) K	R_T = V/I	1/T	$\ln R_T$

Graphs :





Calculations :

We have,

$E_g = 2 . k . \beta$

$= 2 \times 1.37 \times 10^{-23} \times$ (slope of graph of ln R_T Vs 1/T)

= ……………. Joules

= …………….. Electron Volt

Result :

The energy gap of given semiconductor diode is ……………… eV.

Theory :

Solids are classified according to energy band structure. It consists of two bands, namely valence band and conduction band separated by a gap known as forbidden energy gap (E_g). The band which is occupied by valence electrons and has highest occupied band energy at absolute zero temperature is called valence band. It may be partially or completely filled up depending upon the nature of the solid.

The lowest unfilled energy band at absolute zero temperature is called conduction band.

The electrons in valence band can be transferred to conduction band by providing them with energy equal to E_g.

On the basis of forbidden energy gap, solids are classified into three groups, namely Conductors, Semiconductors, Insulators.

In conductors, $E_g = 0$ eV.

In semiconductors, $0 < E_g < 1$ eV.

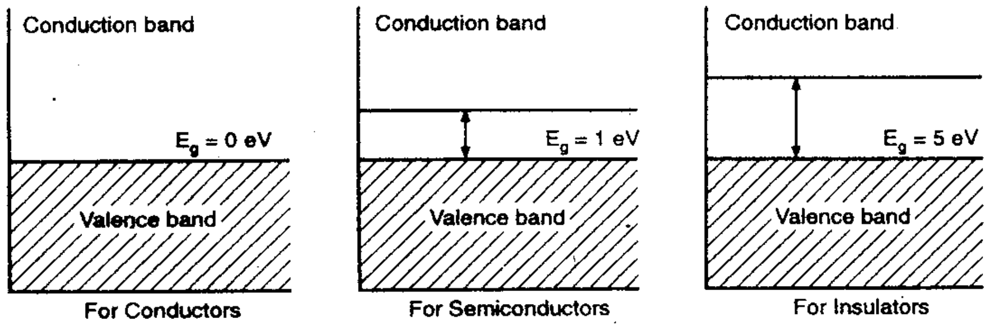
In insulators, $E_g > 5$ eV.

Germanium and silicon are two good examples of semiconductors. In silicon, the energy gap is 1.1 eV, whereas that in germanium is 0.72 eV.

In a semiconductor at absolute zero, the conduction band is empty and the valence band is filled. As temperature increases, the valence band electrons gain energy, and cross over the forbidden gap to move into the conduction band. As the number of electrons available for conduction increases with temperature, the resistivity of the semiconductor decreases. We have, at temperature $T > 0^0$K,

$$\rho_T = \rho_0 \exp\left(\frac{E_g}{2kT}\right)$$

where, ρ_T is resistivity at temperature T, ρ_0 is resistivity at absolute zero, E_g is forbidden energy gap of the semiconductor, and k is Boltzmann constant.



Since resistance of a given specimen is proportional to resistivity, we can write,

$$R_T = R_0 \exp\left(\frac{E_g}{2kT}\right)$$

Taking logarithm on both sides, we get

$$\ln R_T = \ln R_0 + \frac{E_g}{2kT}$$

This equation has the form y = mx + c, where, y = ln R_T and x = 1/T. Thus, the graph of ln R_T Vs 1/T, is a straight line with slope equal to $E_g/2k$ and intercept equal to ln R_0. In this experiment, the above considerations have been used to estimate the forbidden energy gap of the given semiconductor material.

* * *

Questions :

1) Describe in brief the formation of energy bands in solids.
2) Classify the elements into conductors, insulators and semiconductors on the basis of band theory of solids.
3) Explain the terms valence band, conduction band and forbidden energy gap.
4) Give the energy band picture of lithium, beryllium, sodium, diamond and silicon.
5) Derive the expression for conductivity in an intrinsic and extrinsic semiconductor and a metal.

Department of Applied Physics

Experiment No. : ------------------ Date of Performance : ------------------

Name of the Student : --

Division : --------------- Roll No. :------------------

Hall Effect

Aim :

To study the Hall Effect and determine Hall coefficient, carrier density and mobility of given semiconductor material.

Apparatus :

Search coil, calibrated flux meter, millivolt meter battery, rectangular slab of semiconductor crystal, ammeter, connecting wires etc.

Diagram :

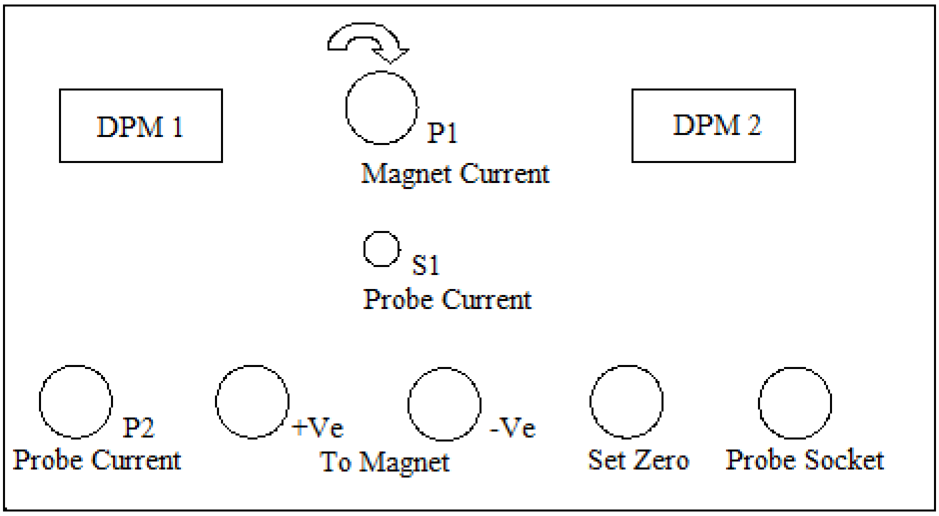


Fig. Hall Effect Set-Up

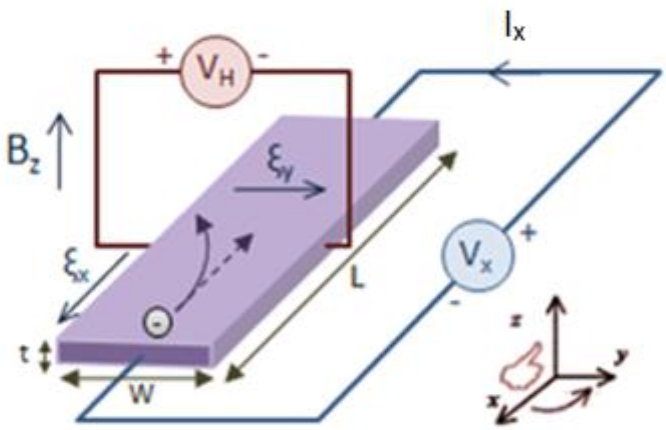


Fig. Circuit Diagram

Formulae :

$$R_H = \frac{V_H}{I_x}\frac{w}{B_z}10^4\ meter^3/coulomb$$

Where, R_H = Hall Coefficient

V_H = Hall voltage measured in volts

I_x = Current measured in amperes

W = Width of the crystal/slab in meters

B_z = Applied magnetic field in Gauss

Carrier density (no. of charge carriers per unit volume), "n" is,

$$n = -\frac{1}{R_H\ e} meter^{-3}$$

Where, e = $1.6x10^{-19}$ coulomb

Hall angle,

$$\phi = \frac{V_H}{V_x}\frac{L}{t}\ rad.$$

Where, L and t are the length and breadth of the crystal in meters.

Mobility,

$$m\mu = \frac{\phi}{B_z} rad.\frac{m^2}{weber}.$$

Procedure :

Precaution for Probe Handling:

The sensing element used in the probe is extremely thin & fragile & can easily be damaged permanently. Special care should be taken while handling probe. To expose the sensor unscrew the transparent cap on the probe. Always restore the cap when the probe is not use. In bigger gaps, the cap need not be removed. While taking measurement in narrow gaps, care must be taken to see that probe does not brush against the gap sides.

General Procedure Before Starting the Instrument :

1) Connect electromagnet wires Red & Black front panel of Instrument mark as +ve and –ve.
2) Connect probe into probe socket front panel of Instrument.
3) Keep all knobs i.e. P1, P2, P3 to min. position.
4) Know switch ON the instrument i.e. 230v/50Hz input.
5) Keep the Hall Probe much away from the electromagnet & adjust zero for min. probe current reading.
6) Insert the probe into probe holder & keep the probe exactly in center of two pole pieces.

Procedure for probe current Vs. Hall Voltage (@ constant magnetizing current) :

1) Keep the S1 switch on front panel to upward position i.e. on magnetizing current record the magnetizing current on digital panel meter i.e. on left side of instrument.
2) Record the magnetizing current.
3) Keep S1 switch downward position i.e. on probe current position i.e. probe (I) & record the min valve of probe current.
4) Keep probe current at minimum position and adjust zero by potentiometer P3 until the DPM2 shows zero reading.
5) Keep the Hall Probe exactly in center of pole pieces of electromagnet & record the Hall Voltage (mv) for minimum value probe current.
6) Now vary the probe current and record Hall output voltage on DPM2. Magnetizing current constant.
7) Keeping magnetizing current for different current constant & plot probe current Vs. Hall O/P voltage.

Procedure for magnetizing current Vs. Hall Voltage (@ constant probe current) :

1) Keep the S1 down ward position adjust pot P2 for probe current constant, keep the probe current at any desired value & adjust zero, precaution to be taken that probe should be kept much away from the electromagnet.
2) Now put S1 switch upward that is on magnetizing current & set the current for minimum value record on DPM1
3) Insert the probe into probe holder & keep the probe exactly in centre of pole pieces of electromagnet.
4) Vary the magnetizing current & record Hall O/P voltage on DPM2
5) Further varying the probe current plot magnetizing current Vs Hall O/P voltage graph.

Observation Table :

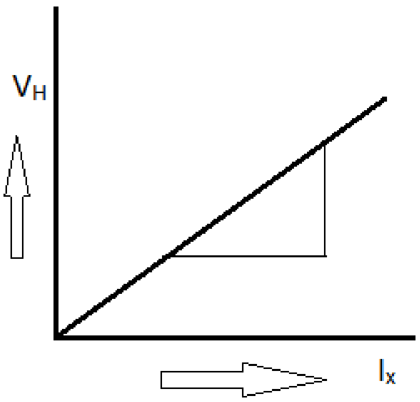
(a) Probe Current Vs. Hall Voltage (@ Magnetizing current =) :

Sr. No.	**Probe Current, I (mA)**	**Hall Voltage, V_H (V)**

(b) Magnetizing Current Vs. Hall Voltage (@ Probe current =) :

Sr. No.	**Magnetizing Current, I (mA)**	**Hall Voltage, V_H (V)**

Graph :



Calculations :

Results :

Hall Coefficient, R_H = met^3/coul

No. Of charge carriers, n =

Hall angle, φ = rad

Mobility mμ = rad. Met^2/weber

Theory :

The Hall effect is the production of a voltage difference i.e. the Hall voltage across an electrical conductor, transverse to an electric current in the conductor and a magnetic field perpendicular to the current. It was discovered by Edwin Hall in 1879.

The Hall coefficient is defined as the ratio of the induced electric field to the product of the current density and the applied magnetic field. It is a characteristic of the material from which the conductor is made, since its value depends on the type, number and properties of the charge carriers that constitute the current. A charge carrier is a free particle carrying an electric charge, especially the particles that carry electric currents in electrical conductors.

If a conductor carrying a current is immersed in a magnetic field, the charge carriers in the conductor may experience an additional force due to this magnetic field. The charge carriers are deflected to the side of the conductor as a result of this force, creating a potential difference across the conductor at right angles to the current flow. This process is known as the Hall Effect.

In this situation, the electrons are forced downward by the action of the magnetic field. This causes the top of the conductor to become positive with respect to the bottom. This causes a downward directed electric field to develop in the conductor. This field produces an upward force on the electrons. Equilibrium is reached when the electric force is equal to the magnetic force. This condition is satisfied when

$$eE = evB$$

The induced electric field produces a potential difference across the conductor at a right angle to the direction of current flow. Its magnitude is

$$\mathbf{V_H = Ew = vBw}$$

Where, **w** is the width of the conductor. This implies that the Hall voltage is proportional to both the electron drift velocity and the applied field. Note also that in this instance that the Hall-induced potential decreases from top to bottom. Suppose instead that the charges carrying the current had been positive. In this case, the charges average drift velocity would be in the same direction as the current; the magnetic force on them would again force them in the downward direction. In this case, the Hall potential then increases from top to bottom. The sign of the Hall voltage can therefore be used to determine the sign of the charge carriers in a conductor.

Questions:

1. What is Hall Effect?
2. How do you define Hall Coefficient?
3. What is Mobility?
4. What do you mean by Charge Carriers?
5. What is the drift velocity of the carriers?

Experiment No. : ------------------ Date of Performance : ------------------

Name of the Student : --

Division : --------------- Roll No. :------------------

Solar cell characteristics

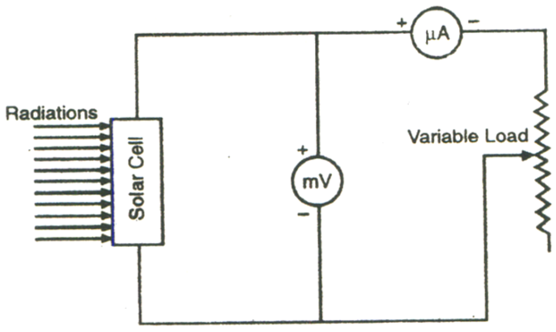
Aim :

To obtain I-V characteristics and determine fill factor of the given solar cell.

Apparatus :

Solar cell, variable load, digital multimeter, micrometer, etc.

Circuit Diagram :



Formulae :

Incident power, $P_{in} = \frac{Wattage\ of\ bulb}{4\pi R^2}\ x\, Surfacea\ area\ of\ solar\ cell$

Fill factor, $FF = \frac{I_m x V_m}{I_{sc}\ x\ V_{oc}}$

Efficiency, $\eta = \frac{I_m\ x V_m}{P_{in}}\ x 100\%$

Where, R = Distance between bulb and solar cell

I_m = Current corresponding to maximum power point

V_m = Voltage corresponding to maximum power point

I_{sc} = Short circuit current

V_{oc} = Open circuit voltage

Series Resistance, $R_s = \frac{1}{slope}$ of the graph I Vs. ΔV

Parallel Resistance, R_p = slope of the graph V Vs. ΔI

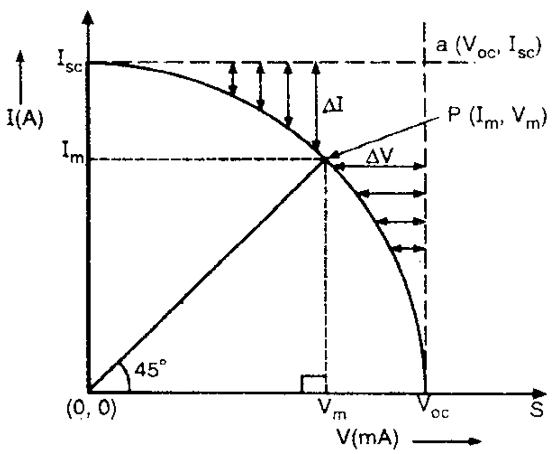
Procedure :

1) Connect the circuit, as shown in circuit diagram and get it checked.
2) Keep maximum load and measure corresponding voltage and current.
3) Start reducing the load and measure corresponding voltage and current. Take enough readings for graph.
4) Minimize the load and measure the corresponding voltage and current.
5) Plot a graph of I Vs. V. Find I_m, V_m and I_{sc} and V_{oc} from graph.
6) Use the given formula to estimate the incident power. Calculate fill factor and efficiency for the given solar cell.
7) From the graph, note readings (ΔV, I) and (V, ΔI), as shown in the figure.
8) Plot the graphs of I Vs. ΔV and V Vs ΔI. Calculate the series and parallel resistance using the given formulae.

Observation Table :

Sr. No.	Voltage (mV)	Current (μA)	Sr. No.	Voltage (mV)	Current (μA)

Graph :

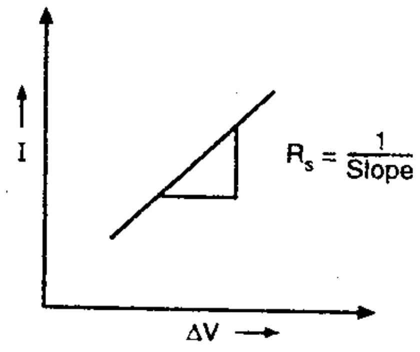


Observations from Graph :

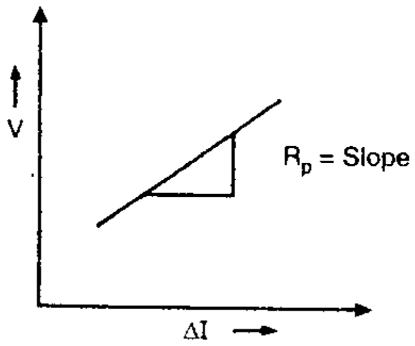
1) Open circuit voltage (V_{oc}) = ……………. mV
2) Short circuit current (I_{sc}) ...= …………….. μA
3) Current corresponding to maximum power (I_m) = ……………… μA
4) Voltage corresponding to maximum power (V_m) = ……………… mV

Sr. No.	I (μA)	ΔV (mV)	V (mV)	ΔI (μA)

Graphs :



(i) I Vs ΔV



(ii) V Vs ΔI

Calculations :

1) Incident power, $$P_{in} = \frac{Wattage\ of\ bulb}{4\pi R^2}\ x\, Surfacea\ area\ of\ solar\ cell$$

P_{in} = ……………… watt

2) Fill factor, $$FF = \frac{I_m x V_m}{I_{sc}\ x\ V_{oc}}$$

FF = ……………

3) Efficiency, $$\eta = \frac{I_m \, x V_m}{P_{in}} \; x100\%$$

η = ……………… %

4) Series Resistance, $$R_s = \frac{1}{slope}$$ of the graph I Vs. ΔV

= …………….. Ω

5) Parallel Resistance, R_p = slope of the graph V Vs. ΔI

= ……………… Ω

Results :

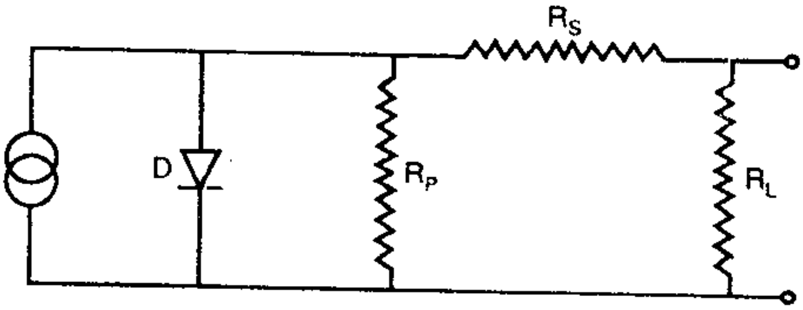
1) Fill factor of the solar cell = …………..
2) Efficiency of the solar cell = ………….. %
3) Series resistance, Rs = ………….. Ω
4) Parallel resistance, Rp = ………….. Ω

Theory :

Solar cell is a P-N junction, which produces a voltage when visible light falls on it. Cosider a P-N junction made up of silicon (Si) having a forbidden band gap of 1.1 eV. If the light from sun or some other visible radiation source is incident upon it, the incident photons having energies greater than 1.1 eV move the electrons from valence band to conduction band. This results production of excess electrons in the conduction band and excess holes in valence band. Suppose that the sunlight is incident on the P-type region of the P-N junction. The incident light produces electron hole pairs in P-region. The extra holes produced in P region are insignificant as compared tot the large number of holes already present in it. Some electrons immediately combine with holes and get neutralized while others shift to the junction boundary.

In P-N junction there exists an electric field directed from N region to P region due tot the development of barrier potential. This electric field makes electrons move from P to N region. Hence an extra negative charge builds up in N-region and extra positive charge in P-region as positive terminal of a battery. The voltage formed is about 0.6 V. If a load resistance R_L is connected across the two terminals, an electric current flows through R_L. Such a current continues to flow as long as light is incident on the junction. A similar process occurs when light is incident on N-region. Current produced depends upon the number of charge carriers produced and therefore on intensity of incident light.

For any power source, the inherent series and parallel resistance are the critical parameters. The equivalent circuit of the solar cell is as shown in the figure below.



Solar energy is a renewable source of energy. Solar cells are used s chargers for batteries used in satellites and earth communication equipment, etc. A solar power system can operate for 24 hours by recharging the batteries during daytime and has applications in earth stations, space probes, etc. Use of solar energy is free from any kind of thermal, chemical and radioactive pollution.

* * *

Questions :

1) " P-N junction is a unidirectional device". Explain. Explain the process that takes in and around the depletion layer.
2) Write a note on solar cell.
3) Discuss applications of a solar cell.
4) Write a note on the construction and characteristics of a solar cell.
5) Explain the working of a solar cell. Give the significance of the cell parameters I_{sc}, V_{oc} and fill factor.

Name of the Student : ---

Division : --------------- Roll No. :------------------

Absorption Coefficient of Sound for Acoustic Materials

Aim :

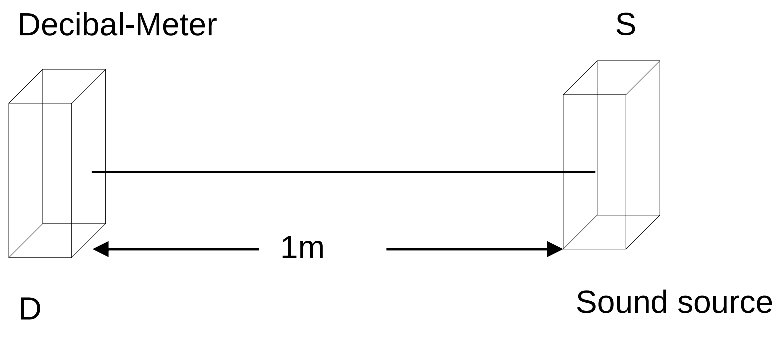
To calculate coefficient of absorption of sound for acoustical materials.

Apparatus :

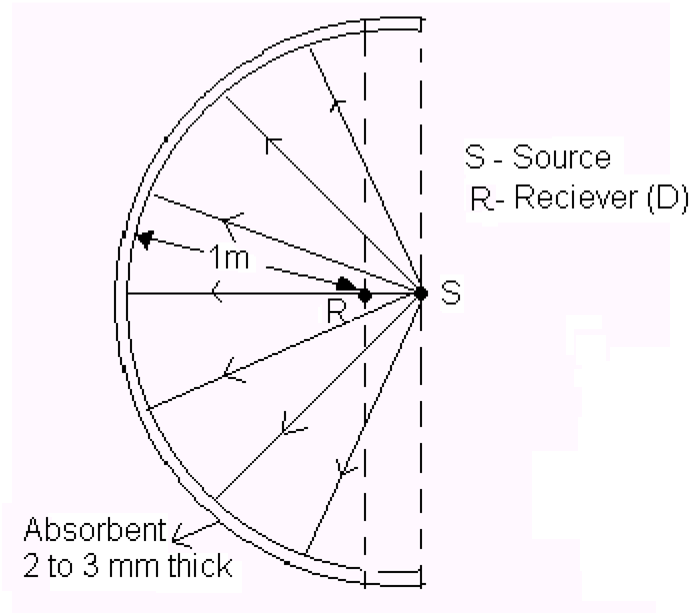
Portable sound source, Portable decibel-meter, different surfaces (Plaster, thermocole, curtains, non-perforated panels of wood, pressed wood fibers), and prefabricated half cylindrical panel.

Diagram :

1. To measure incident sound energy.



2. Spherical Geometry of Sound Transmission from Source to Receiver



Formulae :

When a sound wave strikes a surface, part of it is transmitted and the remaining part is reflected. The property of a sound energy is converted in other form of energy is known as absorption.

The coefficient of absorption ' a ' of a material is defined as the ratio of sound energy absorbed by its surface to that of the total energy incident on the surface. Thus,

$$a = \frac{sound\ energy\ absorbed\ by\ the\ surface}{total\ sound\ energy\ incident\ on\ the\ surface}$$

The coefficient of absorption is expressed in 'open window unit' (O.W.U.) or 'Sabine/m^2'.

Procedure :

1. Measure the amount of sound energy received by the decibel-meter from source of sound as shown in diagram 6.1
2. For this measurement keep the distance between source (S) and receiver (R) 1m.
3. Note down the reading in decibel (dB). Say S.

4. Now using prefabricated half cylindrical panel make experimental set-up as shown in diagram 6.2.
5. Mount plaster material (sheet) on the panel.
6. Using sound source (S) and receiver (R) note down sound energy received after reflection from the surface. Repeat the observation for two more readings. Note down the readings and calculate the average value. Say S_1.
7. Now remove plaster material sheet and place thermo Cole sheet. Take three readings for this surface. Calculate the average value. Say S_2.
8. Finally replace plaster material sheet by curtain (cotton) by mounting it on panel. Take three readings in receiver R. Calculate the average value Says S_3.
9. Using the formula calculate coefficient of absorption for Plaster-material, Thermocole and curtain (cotton).

Observation Table :

Reading in decibel meter when sound energy is received directly = S = …………
dB.

Table for Sound energy received after absorption from different surfaces.

Sound energy absorbed	**Reading in Decibel-meter**			**Average**
Name of Material	1	2	3	**Reading**
1) Sponge				S_1 = …………..dB
2) Thermocole (T)				S_2 = …………..dB
3)				S_3 = …………..dB

Result :

The calculated values of absorption coefficient are,

For I) Sponge Material = …………………… O.W.U or Sabine/m^2.

For II) Thermocole material= ……………… O.W.U or Sabine/m^2.

* * *

Questions :

1) Write a note on sound.
2) Explain the concept of reflection & absorption of a sound.
3) What is Doppler Effect.
4) Explain the concept of Echo & Reverberation.

