PHYSICS LAB

Odd/Even Semester **Session** 2021 – 22

ENGINEERING PHYSICS (LAB)-EAS162/262

TEERTHANKER MAHAVEER UNIVERSITY

FACULTY OF ENGINEERING

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Head
Dept. of Physics
College of Engineering
Teerthanker Mahaveer University
Moradabad

Semester I
Engineering Physics (Lab)

Course Code: EAS162/262

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LIST OF EXPERIMENTS:

Note: Select any ten experiments from the following list.

1. To determine the wavelength of monochromatic light by Newton's ring.
2. To determine the wavelength of monochromatic light by Michelson-Morley experiment.
3. To determine the wavelength of monochromatic light by Fresnel's Bi-prism.
4. To determine the Planck's constant using LEDs of different colours.
5. To determine the specific rotation of cane sugar solution using Polarimeter.
6. To verify Stefan's Law by electrical method.
7. To study the Hall Effect and determine Hall coefficient and mobility of a given semiconductor material using Hall-effect set up.
8. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's experiment.
9. To compare Illuminating Powers by a Photometer.
10. To determine the frequency of A.C. mains by means of a Sonometer.
11. To determine refractive index of a prism material by spectrometer.
12. To determine the Flashing & Quenching of Neon bulb.
13. Determination of Cauchy's constant by using spectrometer.
14. To study the PN junction characteristics.
15. To determine the resolving power and dispersive power by a prism.
16. To determine the value of Boltzmann Constant by studying Forward Characteristics of a Diode.
17. Study the characteristics of LDR.
18. To study the characteristics of a photo-cell.

Books:

1. B.Sc. Practical Physics, Gupta and Kumar, Pragati Prakashan.
2. B.Sc. Practical Physics, C.L. Arora, S. Chand & Company Pvt. Ltd.

***Latest editions of all the suggested books are recommended.**

Evaluation Scheme of Practical Examination:
Internal Evaluation (50 marks)

Each experiment would be evaluated by the faculty concerned on the date of the experiment on a 4-point scale which would include the practical conducted by the students and a Viva taken by the faculty concerned. The marks shall be entered on the index sheet of the practical file.

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Evaluation scheme:

PRACTICAL PERFORMANCE & VIVA DURING THE SEMESTER (35 MARKS)				ON THE DAY OF EXAM (15 MARKS)		TOTAL INTERNAL (50 MARKS)
EXPERIMENT (5 MARKS)	FILE WORK (10 MARKS)	VIVA (10 MARKS)	ATTENDANCE (10 MARKS)	EXPERIMENT (5 MARKS)	VIVA (10 MARKS)	

External Evaluation (50 marks)

The external evaluation would also be done by the external Examiner based on the experiment conducted during the examination.

EXPERIMENT (20 MARKS)	FILE WORK (10 MARKS)	VIVA (20 MARKS)	TOTAL EXTERNAL (50 MARKS)

EXPERIMENT NO. 01

NEWTON'S RING

Objective:- To determine the wavelength of sodium light by Newton's Ring.

Apparatus:- A Plano-convex lens of large radius of curvature, optically arrangement for Newton's rings, plane glass plate, sodium lamp and traveling microscope.

Theory:-

The optical arrangement for Newton's Ring is shown in Fig.(1). A wedge shape air film in formal between Plano-convex lens and glass plate. Interference take place between light reflected from concave surface of lens and upper surface the plate as shown in Fig.(2). In this Experiment the Fringes are of equal thickness i.e. why fringes are circular as shown in Fig.(3).

In this experiment path difference between reflected rays from lens and plate is $\approx 2\mu t$. Locus of points having the same thickness then full on a circle having. Its center at the point of contact. Thus, the thickness of the film is the same at all points on any circle having 0 as the center of the fringes one therefore circular as shown in Fig.(3).

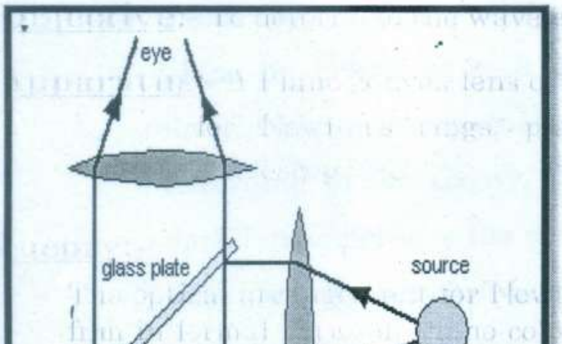
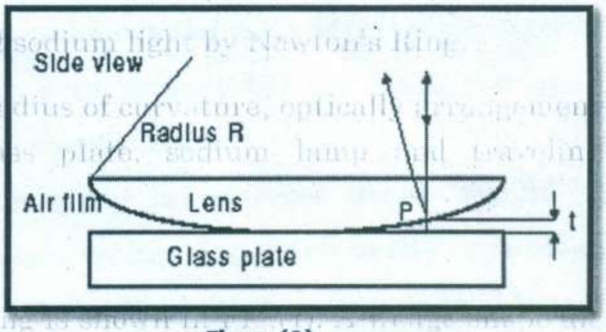


Figure 1



Figure(2)

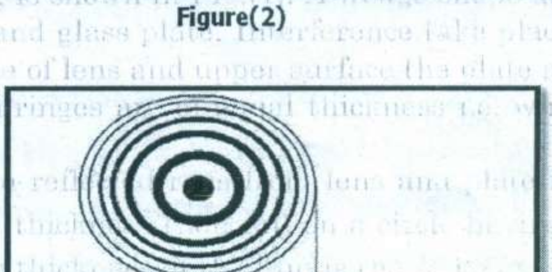


Figure.(3)

Formula used: - The wavelength of Sodium light is given by,

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

Where D_{n+p} = Diameter of (n+p) th ring.

D_n = Diameter of nth ring.

p = An integer numbers of the ring.

R = Radius of curvature of the curved face of the Plano convex lens.

Procedure: -

1. If a point source is used only then we require a convex lens otherwise using an extended source, the convex lens is not required.
2. Before starting the experiment, the glass platesG1, G2 & the Plano convex should be thoroughly cleaned.
3. The center of lens L2 is well illuminated by adjusting the inclination of glass plate G1 at 45 deg.
4. Focus the eyepiece on the crosswire and move the microscope in the vertical plane by means of rack & pinion arrangement till the rings are quite distinct clamp the microscope in the vertical scale.
5. According to the theory, the center of the interference fringes should be dark but sometimes the center appears white, this is due to the presence of dust particles between glass plate G2 and Plano convex lens L2.in this case lens should be again cleaned.
6. More the microscope in a horizontal direction to one side of the fringes. Fix up the cross wire tangent to the ring and note this reading. Again the microscope is moved in the horizontal plane and the crosswire is fixed tangentially to the successive bright fringes noting the vernier reading till the other side is reached.

Observation Table: -

Least count of the traveling microscope = 0.001cm

Table for determination of $[D^2_{(n+p)} - D_n^2]$

No of rings	Microscope reading		Diameter (a-b)	$D^2=(a-b)^2$	$D_{n+p}^2 - D_n^2$	Mean cm²	p
	Left end a cm.	Right end b cm.					
16							
14							
12							
10							
8							
6							
4							
2							

Calculations:-

The wavelength of sodium light is given by-

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

Result: - The mean wavelength of sodium light = -------------------A⁰

Conclusion:-

$$\text{Percentage error} = \frac{\text{(Standard value} \sim \text{Observed Value)} \times 100}{\text{Standard Value}}$$

Precautions: -

1. The lens used should be large radius of curvature.
2. Before measuring the diameter of rings the range of the microscope should be properly adjusted.
3. Cross wire should be focused on a bright ring tangentially.

Lab Quiz :-

Q1. Define Interference.

Ans. Redistribution of energy is called Interference.

Q2. What are the types of interference?

Ans. There are two Types of interference
(1)Division of wave front and (2) division of amplitude

Q3. On which type of interference does Newton ring based.

Ans. Division of amplitude.

Q4. Which type of light is used in experiment?

Ans. monochromatic source (Sodium light)

Q5. Why fringes are circular?

Ans In this experiment fringes are of equal thickness due to the locus of the fringes of equal thickness lies on a circle hence it is circular.

Q6. What is the standard wavelength of light used in experiment?

Ans. $5896\ A^0$

Q7. What is the condition for dark central spot?

Ans. At the central spot thickness of film is zero.

Q8. What are the uses of this experiment?

Ans. (1) To determine the refractive index of liquid,
(2)To determine the wavelength of light
(3)To determine the radius of curvature of lens.

Q9. Which type of lens is used in experiment.

Ans. Plano convex lens

Q10. What happened when experiment would be performed by white light.

Ans. A few distinct colored rings be seen

EXPERIMENT NO. 04

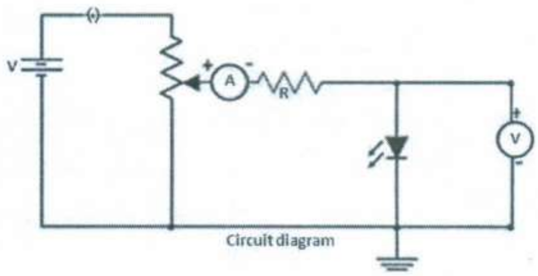
PLANK'S CONSTANT

Object: - Determination of Planck's constant.

Apparatus:- 0-10 V power supply, a one way key, a rheostat, a digital milliammeter, a digital voltmeter, a 1 K resistor and different known wavelength LED's (Light-Emitting Diodes).

Theory:- Planck's constant (h), a physical constant was introduced by German physicist named Max Planck in 1900. The significance of Planck's constant is that 'quanta' (small packets of energy) can be determined by frequency of radiation and Planck's constant. It describes the behavior of particle and waves at atomic level as well as the particle nature of light.

An LED is a two terminal semiconductor light source. In the unbiased condition a potential barrier is developed across the p-n junction of the LED. When we connect the LED to an external voltage in the forward biased direction, the height of potential barrier across the p-n junction is reduced. At a particular voltage the height of potential barrier becomes very low and the LED starts glowing, i.e., in the forward biased condition electrons crossing the junction are excited, and when they return to their normal state, energy is emitted. This particular voltage is called the **knee voltage** or the **threshold voltage**. Once the knee voltage is reached, the current may increase but the voltage does not change.



Circuit diagram

The light energy emitted during forward biasing is given as,

$$E - \frac{hc}{\lambda} \qquad (1)$$

Where
c -velocity of light.
h -Planck's constant.
λ -wavelength of light.

If V is the forward voltage applied across the LED when it begins to emit light (the knee voltage), the energy given to electrons crossing the junction is,

$$E = eV \qquad (2)$$

Equating (1) and (2), we get

$$eV = \frac{hc}{\lambda} \qquad (3)$$

Where, $e = 1.6 \times 10^{-19}$ C (electron charge) and $c = 3\times10^{8}$ m/sec (speed of light)

We then get: $h = \frac{eV\lambda}{c}$ (4)

Procedure:-

1. Connected the L.E.D. to the jack provided on the front panel and switch ON the unit
2. Take the different voltage and current measurement of LED (as tabulated below) for V-I characteristic of LED.:
3. Take different LEDs and follow step 2.

Observation Table:- Table –I

Voltage (Volts)	Current (mA)			
	Green	**Blue**	**Red**	**Yellow**
0.0				
0.50				
1.00				
1.50				
1.55				
1.60				
1.65				
1.70				
1.75				
1.80				
1.85				
1.90				
1.95				
2.00				

Table - II

Colour of LED	Wavelength (λ) nm	Knee voltage (V) volt	λxV	h = eλV/c

Calculation:-

Use the values of table II in given equation

$$h = \frac{e\,V\,\lambda}{c}$$

$[\ c = 3\times10^{8} m/s$ and $e = 1.6\times10^{-19} C\ ]$

Result:- Observed value of Planck's constant is h=…………………Js.

Conclusion:-

Percentage error: = (Standard value ~ Observed value) x 100 / Standard value

Precautions :-

1. Note the knee voltage carefully.
2. Take the reading, when LED just glows.

Suggested Questions:

Q.1 What is the full form of LED?

Ans: Full form of LED is Light Emitting Diode.

Q.2 What is the standard value of h.

Ans: $h = 6.6\times10^{-34}$ Js.

Q.3: What is LED?

Ans: A ***light-emitting diode*** (***LED***) is a semiconductor device that emits visible light when an electric current passes through it.

Q.4 What is the learning outcome of this practical?

Ans: Using this practical we can find out the value of Planck constant using LED.

EXPERIMENT NO. 05

POLARIMETER

Object: - To determine the specific rotation of cane sugar solution with the help of polarimeter.

Apparatus: - Polarimeter, a balance, measuring cylinder, beaker, source of light and polarimeter tube.

Formula used: - The specific rotation of the plane of polarization of sugar dissolved in water can be determined by the following formula.

$$S = \frac{\theta \times V}{m \times l}$$

Where, θ = rotation produced in degrees.

l = length of tube in decimeter.

m = mass of sugar in gms dissolved in water.

V = volume of sugar solution.

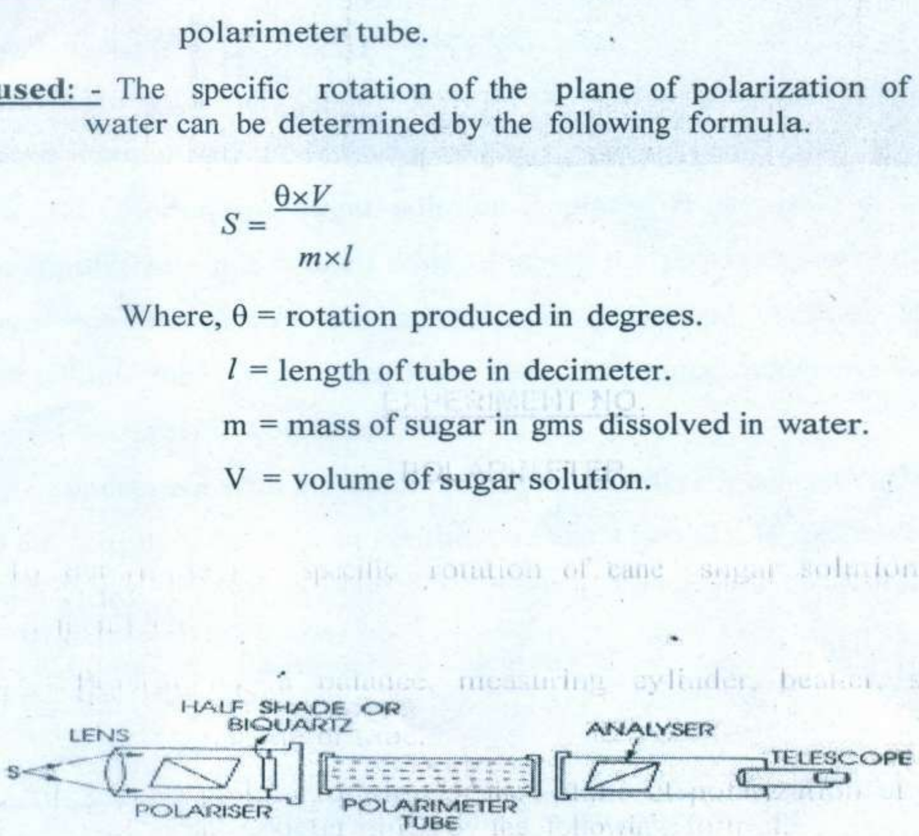


Fig.

Figure 1

Procedure: -

1. If the polarimeter is employing a half shade device, a monochromatic source should be used and if bi quartz device is used then white light can be used.
2. Take the polarimeter tube and clean well both the sides such that it is free from dust. Now fill the tube with pure water and see that no air bubble is enclosed it. Place the tube in its position inside the Polarimeter.

3. Switch on the source of light and look through the eyepiece. Two halves of unequal intensity is observed. Rotate the analyzer until two halves of the field appears equal bright. Take the reading of main scale as well as vernier scale and find out the total reading.
4. Prepare the sugar solution of unknown strength. The procedure for preparing it can be seen under the heading observations.
5. Take the polarimeter tube and remove the pure water and fill it with the prepared sugar solution and again place it in the polarimeter.
6. Rotate the analyzer to obtain the equal intensity position, first in clockwise direction and then in anti-clockwise direction.

   [When the tube containing sugar solution is placed in the path of the polarized light, the plane of polarization is rotated which disturbs the previous position.]

   Note down the position of the analyzer on main and vernier scales in the two directions. Find the mean reading. The difference between this and previous reading gives the specific rotation.
7. Repeat the experiment with the sugar solutions of different concentrations.
8. Measure the length of the tube in centimeters and change it in decimeters.

Observation Table: -

Least count of polarimeter = 0.1 degree = 6′

Table 1

Analyzer reading with pure water						
Clockwise			**Anticlockwise**			**A= (X+Y)/2 deg**
M.S.	**V.S.**	**Total X deg**	**M.S.**	**V.S.**	**Total Y deg**	

Table 2

Concentration of sugar solution	Analyzer reading with sugar solution							
	Clockwise			Anticlockwise			B = (X'+Y')/2 deg	θ=A~B
	M.S	V.S.	Total X' deg	M.S	V.S.	Total Y' deg		

Calculations:--

$$S = \frac{\theta \times V}{m \times l} = \text{---------------deg/dm/kg/m}^3$$

Result: - The specific rotation for cane sugar at a room temperature using sodium light is -----------

Conclusion:-

Precaution:-

1. The polarimeter tube should be well cleaned.
2. Whenever solution is changed, rinse the tube with the new solution under examination.
3. The position of analyzer should be set accurately.
4. The temperature and wavelength of light used should be stated.
5. Reading should be taken when halves of the field of view becomes equally illuminate

Lab Quiz :-

Q. 1 What do you mean by polarization?

Ans. The lack of symmetry about the direction of propagation of light is known as the polarization of light.

Q. 2 What are optical rotations?

Ans . The rotations produced by a decimeter long column of the liquid containing 1 gm of active substance in 1 cc of the solution.

Q. 3 Define plane of vibration and plane of polarization.

Ans. The plane of polarization is that plane in which no vibrations occur and the plane in which vibrations occur known as plane of vibration. The vibrations occur at the right angle to the plane of polarization.

Q. 4 What do you mean by double refraction?

Ans. When a ray of light is refracted by a crystal of calcite it gives two refractive rays this phenomenon is known as double refractions.

Q. 5 What is nicol prism?

Ans. It is an optical device which is made by calcite crystal to produce and analyze the plane polarized light .

Q. 6 What do you mean by Snell's law?

Ans. The sine of the angle of incidence to sine of the angle of refraction is equal to the refractive index of the material.

Q. 7 What is mean by plane polarized and unpolarized light?

Ans. The plane polarized light is the light in which the vibrations take place only along one straight line perpendicular to the direction of propagation of light while in unpolarized light vibrations take place along all possible straight lines perpendicular to the direction of propagation of light.

Q.9 What are the ordinary and extra ordinary lights?

Ans Ordinary light obeys Snell's law while extra ordinary doesn't obey the Snell's law.

EXPERIMENT NO. 06 08

Aim of the experiment: To determine the frequency of electrically maintained tuning fork by Melde's experiment.

Apparatus required: Electrically maintained tuning fork, Light weight pan, Weight box, Analytical balance, Power supply, Light weight string, Stand with clamp and pulley.

Theory:

1. Standing waves in strings and normal modes of vibration:

When a string under tension is set into vibrations, transverse harmonic waves propagate along its length. The speed of the wave in the stretched string depends on the tension in the string and mass per unit length of the string and is given by:

$$v = \sqrt{\frac{T}{\mu}} \quad (1)$$

where T is the tension in the string which is equal to Mg. M is the mass suspended on the string and g is the acceleration due to gravity and μ is the mass per unit length of the string, given by $\mu = m_s/L_o$. m_s is the mass of the string and L_o is the total length of the string.

A string can be set into vibrations by means of an electrically maintained tuning fork. When the other end of the string is clamped to a rigid support (pulley in present case), reflected waves will also exist. The incident and reflected waves will superimpose to produce transverse stationary waves in the string. The string will vibrate in such a way that the clamped points of the string are nodes and the anti-node exists at the middle.

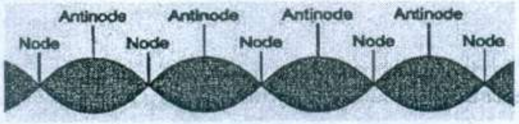


Figure 1. Schematic representation of standing waves showing nodes and antinodes.

The loops are formed from the end of the rigid support where it touches the pulley to the position where it is fixed to the prong of tuning fork. If l is the length of the string between two successive nodes, then

$$l = \frac{\lambda}{2} \qquad (2)$$

where, λ is the wavelength of the traversing wave. The frequency (f) of the vibration is given by

$$f = \frac{v}{\lambda} = \frac{v}{2l} \qquad (3)$$

substituting the value of v from Eq. (1), we get

$$f = \frac{1}{2l}\frac{T}{\mu} = \frac{1}{2l}\sqrt{\frac{T}{\mu}} \qquad (4)$$

2. *Transverse mode arrangement.*

In this arrangement, the vibrations of the prongs of the tuning fork are in the direction perpendicular to the length of the string. The experimental setup with transverse mode arrangement is shown in Figure 2.

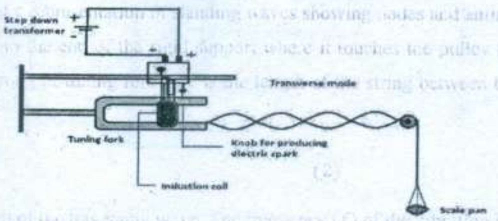


Figure 2: Experimental setup with tuning fork in transverse mode arrangement.

In transverse mode, the string also completes one vibration when the tuning fork completes one. Hence in this mode, frequency of the tuning fork is equal to the frequency of the string which is same as Eq. 4.

$$f = \frac{1}{2l}\sqrt{\frac{T}{\mu}} = \frac{1}{2l}\sqrt{\frac{Mg}{\mu}} \qquad (5)$$

where, M is the mass suspended on the string. $M = m + M'$. m is the mass of the weights placed on the scale pan and M' is the mass of the scale pan attached to the string. If 'P' loops are formed in length 'L' (between two fixed ends) of the thread, then $l = L/P$. Thus, Eq. 5 can also be expressed as,

$$f = \frac{P}{2L}\sqrt{\frac{Mg}{\mu}} \qquad (6)$$

3. *Longitudinal mode arrangement.*

In this arrangement, the tuning fork is set in such a manner that the vibrations of the prongs are parallel to the length of the string. The experimental setup with longitudinal mode arrangement is shown in Figure 3.

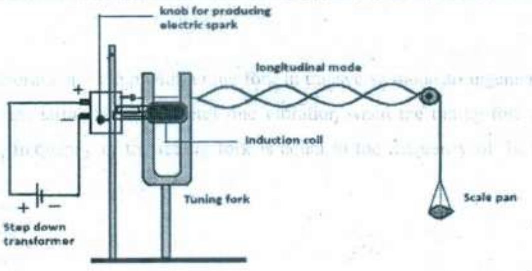


Figure 3: Experimental setup with tuning fork in longitudinal mode arrangement.

In longitudinal mode, the string completes half of its vibration when the tuning fork completes one. Hence in this mode, frequency of the tuning fork is double the frequency of the string and is given as

$$f = \frac{P}{L}\sqrt{\frac{Mg}{\mu}} \qquad (7)$$

Procedure:

1. Find the mass of the scale pan M' and arrange the apparatus as shown in figure.
2. Excite the tuning fork by switching on the power supply (advisable to use voltage more than 6V)
3. Adjust the position of the pulley in line with the tuning fork.
4. Change the load in the pan attached to the end of the string.
5. Adjust the applied voltage so that vibrations and well defined loops are obtained.
6. The tension in the string increases by adding weights in the pan slowly and gradually. For finer adjustment, add milligram weight so that nodes are reduced to points at the edges.
7. Count the number of loop and the length of each loop. For example, if 4 loops formed in the middle part of the string. If 'L' is the distance in which 4 loops are formed, then distance between two consecutive nodes is $L/4$.
8. Note down the weight placed in the pan and calculate the tension T.
9. Tension, $T = (\text{wts. on the pan} + \text{wt. of pan})\, g$.
10. Repeat the experiment for longitudinal and transverse mode of vibrations.
11. Measure one meter length of the thread and find its mass to find the value of mass produced per unit length (m_s).

Observations and calculations:

Mass of the pan, M' =……… gm

Mass per unit length of the string,

μ =……… gm/cm

For transverse mode arrangement:

Frequency

$$f = \frac{P}{2L}\sqrt{\frac{Mg}{\mu}} \quad (8)$$

Table-1: Frequency of transverse mode arrangement

S.No.	Weight (M) gm	No. of loops (P)	Length of thread (L) cm	Length of each loop (L/P) cm	Tension (T) ($m + M'$) gm	Frequency (f) Hz
1						
2						
3						

Mean frequency= --------- Hz

For longitudinal mode arrangement

Frequency

$$f = \frac{P}{L}\sqrt{\frac{Mg}{\mu}} \quad (9)$$

Table-2: Frequency of longitudinal mode arrangement

S.No.	Weight (W) gms	No. of loops (P)	Length of thread (L) cms	Length of each loop (L/P) cms	Tension (T) (W+w) gms	Frequency (f) Hzs
1						
2						
3						

Mean frequency= --------- Hz

Precautions:

1. The thread should be uniform and inextensible.
2. Well defined loops should be obtained by adjusting the tension with milligram weights.
3. Frictions in the pulley should be least possible.

Experiment No 10

Object: To determine the frequency of AC mains using a sonometer and an electro-magnet.

Apparatus: Sonometer with steel wire, an electro magnet, a step down transformer, balance, weight box and a clamp stand.

Formula-

$f = (1/4l)(T/m)^{1/2}$,

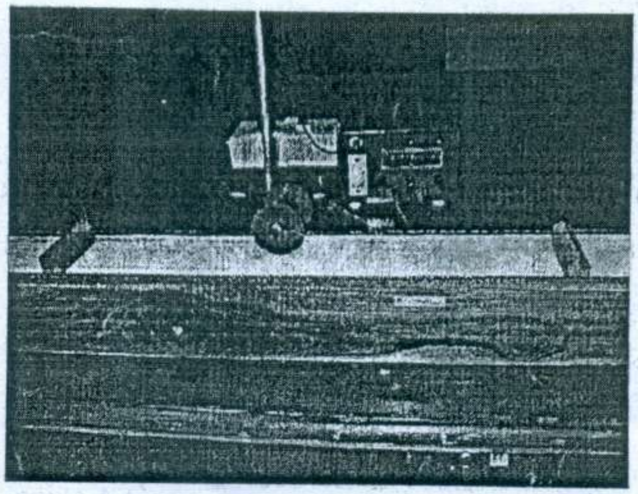
where

f is the frequency of the mains A.C

l is the length of the wire vibrating in resonance with A.C oscillations,

m is the mass of wire per unit length,

T is the tension in the wire = M g, here M is the mass hung from the wire



Procedure:

1. Set up the sonometer apparatus.
2. Arrange the electro magnet in a clamp stand and hold it 2-3 mm vertically above the centre of the steel wire of sonometer. Connect the electromagnet to the secondary of the step down transformer. Switch on the A.C mains and test the magnetization of the electromagnet with the help of an iron needle.
3. Cut a V shaped light paper rider about one cm long and 2mm wide. Bring the two knife-edges close to each other and place the paper ride on the wire in between the knifeedges. See that the pole of electromagnet is just above the centre of sonometer wire. Now gradually increase the distance between the two knife-edges till the rider begins to flutter. The wire is now in resonance with the frequency of AC mains supply. Measure the length of the wire.
4. Increase the distance between the two knife-edges by a few centimeters. Repeat the above process by decreasing slowly the distance between the two knife-edges till the rider again flies off. Measure the length of the wire between the two knife-edges again. The mean of the two lengths is true resonant length.
5. Weigh the weights suspended including the hanger with trip scale balance.
6. Increase the weight by half a kilogram and repeat the observation to find the length of wire vibrating in resonance with AC mains supply Take such four sets of observations by changing the load by ½ kg each time.

7. Switch off the AC mains and remove the electromagnet. To find the mass per unit length of wire, adjust the distance between the two knife-edges to be exactly 50 cm apart. Mark with ink a point on the wire at the position of each knife-edge and cut the wire at those points. Find the weight by a sensitive balance. **Or obtain the value of mass per unit length from the Lab Assistant/ Faculty.**

Observations:

So - 2

Length of wire = cm = m
Mass of wire = g = kg
Mass per unit length (m) =

Sl. No.	Load in kg including the mass of hanger (M)	Tension T =Mg	Length of the wire in meter at resonance			$f = \frac{1}{4l}\sqrt{\frac{T}{m}}$
			Length increasing l_1	Length decreasing l_2	Mean length l (in meter)	
1						
2						
3						
4						
5						

Mean frequency of A.C. = Hz
Standard value of frequency of A.C. mains = 50 Hz
Percentage error =

Result: Frequency of A.C. mains is ....Hz

Precautions

1. The magnetization of electromagnet should be checked with an iron needle before starting the experiment.
2. The electro magnet should be clamped close (2-3 mm) and vertically above the centre of vibrating segment of the wire.
3. The sonometer wire should be made of steel so that it is attracted by the electromagnet.
4. Sufficient load should be put on the wire so that it becomes tight.
5. For each load, the resonant length of the wire should be taken at least twice.

EXPERIMENT NO- 11

S – 1

Object : To determine the refractive index of a prism material by spectrometer.

Apparatus required: Spectrometer, prism, mercury lamp, spirit level.

Formula used: (i) The refractive index of the material of the prism is given by the formula:-

$$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

Where A= Angle of prism

δm=Angle of minimum deviation.

Principle: It is based on the phenomenon of dispersion of light, in which white light is split or dispersed in to different colours, when it passes through a prism. Shorter wavelengths (like blue) bend the most while longer wavelengths (like red) bend the least.

Theory: Spectrometer Design:

The Collimeter: The collimeter C consists two hollow concentric metal tubes, one being longer than other. The longer tube carries an achromatic lens L at one end and the smaller tube at the other end. The smaller tube is provided with a slit at the outer end and can be moved in our out the longer tube with the help of rack and pinion arrangement. The slit is adjusted in the focal plane of the lens L to obtain a pencil of parallel rays from the collimeter when light is allowed to be incident upon slit. The collimeter is also provided with two screws for adjusting inclination of the axis of the collimeter. This is rigidly fixed to the main part of the apparatus.

The Prism Table: It is a circular table supported horizontally in the center of the instrument and the position can be read with the help of two verniers attached to it and moving over a graduated circular scale carried by the telescope. The leveling of the prism table is made with the help of three screws provided at the lower surface. The table can be raised or lowered and clamped in any desired position with the help of a screw. The prism table is also provided with a tangent screw for a slow motion. There are concentric circles and straight lines parallel to the line joining two of the leveling screws on the prism table.

S-2

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

Value of one Main Scale Division. x = Degree

Total no. of div. in circular scale. n =

Hence least count of the microscope scre v = x/n= Degree

(b). **Table for the angle of Prism (A)**

Vernier	Telescope Readings for reflection from First face (a) Degree M.S.	V.S.	Total Degree	Second Face (b) Degree M.S.	V.S.	Total Degree	Difference 2A=b-a Degree	Angle of Prism(A) Degree	Mean A Degree
V1									
V2									

(c). **Table for angle of minimum deviation (δm)**

Colour	Vernier	Telescope Readings for Dispersed image M.S.	V.S.	Total Degree	Direct image M.S.	V.S.	Total Degree	Difference δm = b-a Degree	Mean δm Degree
Blue	V1								
	V2								
Green	V1								
	V2								

Calculations:

Using formula from eqn.(3) we can calculate the values of refractive index. n. for all the colours. Refractive index for the material of the prism for different wavelengths is given in the following table

Sr.No.	Colour	Standard Wavelength. λ in Å	Refractive index. μ
1.	Blue	4693	
2.	Green	5461	

Using any two values of wavelengths and n for two colours, we get the values of B and A by using eqn.(2a) and (2b) respectively.

Result:

(i) The refractive indices of the material of prism for various colours are in table above.

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

Value of one Main Scale Division, x = Degree

Total no. of div. in circular scale n =

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

(b). Table for the angle of Prism (A)

Vernier	Telescope Readings for reflection from First face (a) Degree			Second Face (b) Degree			Difference 2A=b-a Degree	Angle of Prism(A) Degree	Mean A Degree
	M.S.	V.S.	Total Degree	M.S.	V.S.	Total Degree			
V1									
V2									

(c). Table for angle of minimum deviation (δm)

Colour	Vernier	Telescope Readings for Dispersed image			Direct image			Difference δm = b-a Degree	Mean δm Degree
		M.S.	V.S.	Total Degree	M.S.	V.S.	Total Degree		
Blue	V1								
	V2								
Green	V1								
	V2								

Calculations:

Using formula from eqn.(3) we can calculate the values of refractive index, n, for all the colours. Refractive index for the material of the prism for different wavelengths is given in the following table

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1.	Blue	4693	
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Using any two values of wavelengths and n for two colours. We get the values of B and A by using eqn.(2a) and (2b) respectively.

Result:

i) The refractive indices of the material of prism for various colours are in table above.

EXPERIMENT NO. 13

Cauchy's Constant

Object: - To determine Cauchy's Constants using a prism and spectrometer.

Apparatus: - Spectrometer, prism, mercury Source and reading lens.

Theory:-

Diagram:-

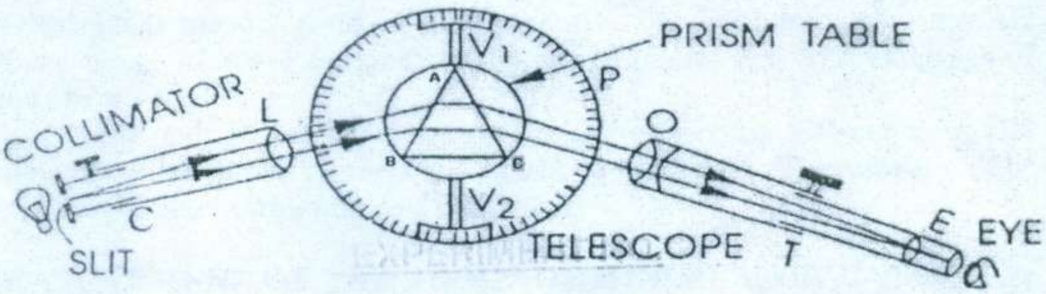


Fig.

Formula used: - The wavelength dependence of refractive index of a dielectricmedium can be approximated by

$$\mu = A + \frac{B}{\lambda^2} \qquad (1)$$

where μ represents the refractive index at wavelength λ andA and B are constants. The Eq. (1) is known as Cauchy's formula and A and B are known as Cauchy's constants. As is obvious from the above formula, a curve between μ and $1/\lambda^2$is a straight line whose intercept with the y axis gives A andslope with respect to the x-axis gives B. Thus we can easily find Cauchy's constants as discussed below.

The refractive index of the prism is given by

$$\mu = \frac{Sin\left(\frac{A + \delta m}{2}\right)}{Sin\left(\frac{A}{2}\right)}$$

Where, A = Angle of the prism,

δm = Angle of minimum deviation

Procedure:-

MEASUREMENT OF THE ANGLE OF THE PRISM

1. Determine the least count of the spectrometer.
2. Place the prism on the prism table with its refracting angle A towards the collimator and with its refracting edge at the center. In this case some of the light failing on each face will be reflected and can be received with the help of the telescope.
3. The telescope is moved to one side to receive the light reflected from the face AB and the cross wire are focused on the image of the slit. The readings of the two verniers are taken.
4. The telescope is moved in other side to receive the light from the face AC and again the cross wire are focused on the image of the slit. The readings of two vernier are noted.
5. The angle through which the telescope is moved or the difference in the two positions gives twice the refracting angle A of the prism. Therefore, half of this angle gives the refracting angle of the prism.

MEASUREMENT OF THE ANGLE OF MINIMUM DEVIATION

1. Place the prism so that its centre coincide with the centre of the prism table and light falls on one of the polished faces and emerges out of the other polished face, after refraction. In this position the spectrum of light is obtained.
2. The spectrum is seen through the telescope is adjusted for minimum deviation position for a particular colour (wavelength) in the following way: -

   Setup telescope at a particular colour and rotate the prism table in one direction, of course the telescope should be moved in such way to keep the spectral line in view. By doing so a position will come where the spectral line recedes in the opposite direction although the rotation of the table is continued in the same direction. The particular position where the spectral line begins to recede in opposite direction is the minimum deviation position for that colour. Note the reading of the two verniers.
3. Remove the prism table and bring the telescope in the line of the collimeter. See the slit directly through telescope and coincide the image of slit with vertical crosswire. Note the readings of two verniers.
4. The difference in minimum deviation position and direct position gives the angle of minimum deviation for that colour.
5. The same procedure is repeated to obtain the angles of minimum deviation for other colors.

Ovservation Table:-

Table for angle of the prism A_0

S.No.	Vernier	Telescope reading for reflection from first face			Telescope reading for reflection from second face			2A= a~b deg.	Mean 2A deg.	A deg.
		M.S. deg.	V.S. deg.	TOTAL a deg.	M.S. deg.	V.S. deg.	TOTAL b deg.			
	V_1									
	V_2									

Table for angle of minimum deviation δ_m

S.No	Color	Vernier	(Dispersed image) Telescope in minimum deviation position			Telescope reading for direct image			Deviation a~b	Mean deviation δ_m deg
			M.S. deg.	V.S. deg.	TOTAL a deg.	M.S. deg.	V.S. deg.	TOTAL b deg.		
1	Violet	V_1								
		V_2								
2	Yellow	V_1								
		V_2								
3	Red	V_1								
		V_2								

Calculation:-

$$\mu = \frac{Sin\ (\frac{A_0 + \delta m}{2})}{Sin\ (\frac{A_0}{2})}$$

Plot Graph: Using the above values draw a graph between μ and $1/\lambda^2$ and determine A and B.

Results: - The values of Cauchy's constant are

A = ...

B = ...

Precautions :-

1. The telescope and collimator should be individually set for parallel rays.
2. Slit should be as narrow as possible.
3. While taking observations, the telescope and prism table should be clamped with the help of clamping screws.
4. Both verniers should be read.
5. The prism should be properly placed on the prism table for the measurement of angle of the prism as well as for the angle of minimum deviation.

Lab Quiz :-

Q.1 What is prism?

Ans : A transparent medium like glass bounded by two triangle and three rectangular smooth surfaces

Q.2 Which colour in the spectrum is having maximum and minimum refractive index?

Ans : Maximum for Violet Colour and Minimum for red colour.

Q.3 What is Refractive index?

Ans : The ratio of sine of angle of incidence in the first medium to the sine of angle of refraction in the second medium.

Q.4 What is the function of Collimator?

Ans : It will produce parallel beam of light.

Q.5 What do you mean by Angle of Prism?

Ans : Angle between two refracting surfaces of the prism.

Q.6 What is Dispersion of Light?

Ans : When the light is allowed to fall on one of the refracting surfaces of a prism , it is split into its constituent colours. This splitting of light into its constituent colours by refraction through prism is called Dispersion of light.

Q.7 What is the main optical action of the prism?

Ans : The main optical action of a prism is to disperse white light into its component parts. Dispersion of light is minor optical action of prism , but main effect of a prism is to deviate a beam of light.

Q.8 What type of material prism is used in this experiment?

Ans : Crown prism.

Q.9 What are the units of Cauchy's constant?

Ans : A is unitless while unit of B is cm^{-2}

Q.10 What type of light do you use in this experiment?

Ans : White light with the help of mercury lamp.

EXPERIMENT NO. 15

DISPERSIVE POWER

Object: - To determine the dispersive power of the material of the prism using mercury light with the help of a spectrometer.

Apparatus: - Spectrometer, prism, mercury Source and reading lens.

Theory:-

Diagram:-

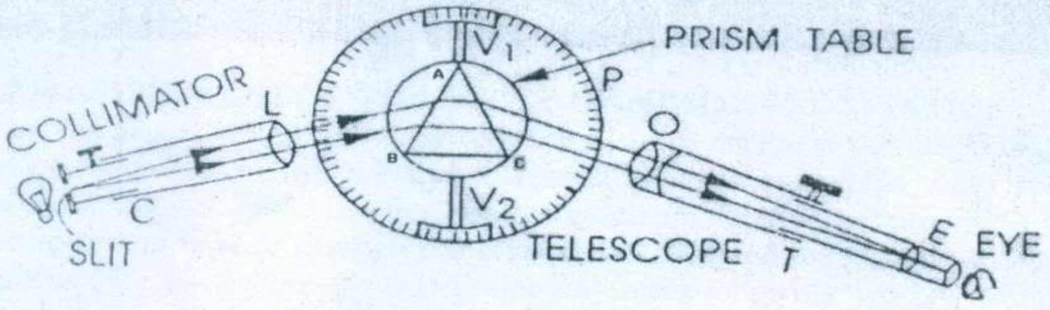


Fig.

Formula used: - The dispersive Power 'ω' of the material of the prism is given by the formula

$$\omega = \frac{\mu_v - \mu_r}{\mu_y - 1}$$

Where, μ_v = refractive index of the material of the prism for violet colour,

μ_r = refractive index of the material of the prism for red colour,

$$\mu_y = \frac{\mu_v + \mu_r}{2}$$

The refractive index of the prism is given by

$$\mu = \frac{Sin\left(\frac{A + \delta m}{2}\right)}{Sin\left(\frac{A}{2}\right)}$$

Where, A = Angle of the prism,

δm = Angle of minimum deviation

Procedure:-

MEASUREMENT OF THE ANGLE OF THE PRISM

1. Determine the least count of the spectrometer.
2. Place the prism on the prism table with its refracting angle A towards the collimator and with its refracting edge at the center. In this case some of the

light failing on each face will be reflected and can be received with the help of the telescope.

3. The telescope is moved to one side to receive the light reflected from the face AB and the cross wire are focused on the image of the slit. The readings of the two verniers are taken.
4. The telescope is moved in other side to receive the light from the face AC and again the cross wire are focused on the image of the slit. The readings of two vernier are noted.
5. The angle through which the telescope is moved or the difference in the two positions gives twice the refracting angle A of the prism. Therefore, half of this angle gives the refracting angle of the prism.

MEASUREMENT OF THE ANGLE OF MINIMUM DEVIATION

1. Place the prism so that its centre coincide with the centre of the prism table and light falls on one of the polished faces and emerges out of the other polished face, after refraction. In this position the spectrum of light is obtained.
2. The spectrum is seen through the telescope is adjusted for minimum deviation position for a particular colour (wavelength) in the following way: -

   Setup telescope at a particular colour and rotate the prism table in one direction, of course the telescope should be moved in such way to keep the spectral line in view. By doing so a position will come where the spectral line recedes in the opposite direction although the rotation of the table is continued in the same direction. The particular position where the spectral line begins to recede in opposite direction is the minimum deviation position for that colour. Note the reading of the two verniers.
3. Remove the prism table and bring the telescope in the line of the collimeter. See the slit directly through telescope and coincide the image of slit with vertical crosswire. Note the readings of two verniers.
4. The difference in minimum deviation position and direct position gives the angle of minimum deviation for that colour.
5. The same procedure is repeated to obtain the angles of minimum deviation for other colors.

Ovservation Table:-

Table for angle of the prism A

S.No.	Vernier	Telescope reading for reflection from first face			Telescope reading for reflection from second face			2A= a~b deg.	Mean 2A deg.	A deg.
		M.S. deg.	V.S. deg.	TOTAL a deg.	M.S. deg.	V.S. deg.	TOTAL b deg.			
	V_1									
	V_2									

Table for angle of minimum deviation δ_m

S.No	Color	Vernier	(Dispersed image) Telescope in minimum deviation position			Telescope reading for direct image			Deviation a~b	Mean deviation δ_m deg
			M.S. deg.	V.S. deg.	TOTAL a deg.	M.S. deg.	V.S. deg.	TOTAL b deg.		
1	Violet	V_1								
		V_2								
2	Yellow	V_1								
		V_2								
3	Red	V_1								
		V_2								

Calculation:-

$$\mu = \frac{Sin\ (\frac{A + \delta m}{2})}{Sin\ (\frac{A}{2})}$$

$$\omega = \frac{\mu_v - \mu_r}{\mu_y - 1}$$

Results: - The dispersive power of prism ω= ....

Conclusion:-

$$\text{Percentage error} = \frac{(\text{Standard value} \sim \text{Observed value}) \times 100}{\text{Standard value}}$$

Precautions :-

1. The telescope and collimator should be individually set for parallel rays.
2. Slit should be as narrow as possible.
3. While taking observations, the telescope and prism table should be clamped with the help of clamping screws.
4. Both verniers should be read.
5. The prism should be properly placed on the prism table for the measurement of angle of the prism as well as for the angle of minimum deviation.

Lab Quiz :-

Q.1 What is prism?

Ans : A transparent medium like glass bounded by two triangle and three rectangular smooth surfaces

Q.2 Which colour in the spectrum is having maximum and minimum refractive index?

Ans : Maximum for Violet Colour and Minimum for red colour.

Q.3 What is Refractive index?

Ans : The ratio of sine of angle of incidence in the first medium to the sine of angle of refraction in the second medium.

Q.4 What is the function of Collimator?

Ans : It will produce parallel beam of light.

Q.5 What do you mean by Angle of Prism?

Ans : Angle between two refracting surfaces of the prism.

Q.6 What is Dispersion of Light?

Ans : When the light is allowed to fall on one of the refracting surfaces of a prism , it is split into its constituent colours. This splitting of light into its constituent colours by refraction through prism is called Dispersion of light.

Q.7 What is the main optical action of the prism?

Ans : The main optical action of a prism is to disperse white light into its component parts. Dispersion of light is minor optical action of prism , but main effect of a prism is to deviate a beam of light.

Q.8 What type of material prism is used in this experiment?

Ans : Crown prism.

Q.9 What is the units of Dispersive power?

Ans : No units.

Q.10 What type of light do you use in this experiment?

Ans : White light with the help of mercury lamp.

Experiment 16

To determine the value of Boltzmann Constant by studying Forward Characteristics of a Diode.

THEORY

Conventional method to determine Boltzman Constant (k) make use of the block body Radiation and its two famous laws i.e. Wien's displacement law and Stefan's law. These methods are time consuming and very often lead to comparatively less accurate results.

The V – I characteristics of a semiconductor diode can be used to determine Boltzman Constant accurately and with simple equipment that can be handled with ease and convenience. The diode equation is given by:

$$I = I_0\left\{\exp\left(\frac{eV}{\eta kT}\right)-1\right\} \quad \ldots(1)$$

where V = voltage across the diode

I = forward current at voltage V

I_0 = reverse saturation current

k = Boltzmann Constant

T = Temperature in Kelvin

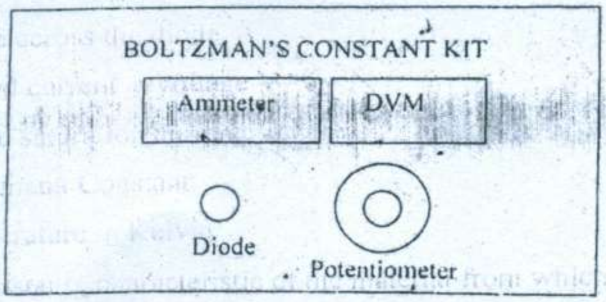
η = a constant, characteristic of the material from which the diode is made, for Ge diode, $\eta = 1$ while $\eta = 2$ for Si diode.

If $V >> kT/e$, the Boltzmann constant can be expressed as

$$k = \frac{e}{\eta T\left(\frac{\Delta \ln I}{\Delta V}\right)} \quad \ldots\ldots\ldots\ldots\ldots (2)$$

where, $\left(\frac{\Delta \ln I}{\Delta V}\right)$ is the slope of the straight line drawn between **V** and **ln(I)**.

The top view of Kit is given below:



The experimental kit consists of following:

(a) A digital dc millivoltmeter (0 – 2 V) to measure the voltage across the diode.

(b) A highly stabilized variable power supply (0 – 5 V)

(c) A current meter (0 – 50 mA) to measure forward bias current in diode.

(d) Silicon diode.

PROCEDURE :

1. Connect the Si - diode (provided with the kit) to main unit.
2. Switch ON the Unit and keep voltage at minimum with the help of potentiometer.
3. Take the different voltage and current measurement of diode.

S.No.	Voltage (V)	Current (mA)

4. Draw the graph between *ln* (I) vs V, it would be a straight line.
5. Calculate Boltzmann Constant from the slope of the graph and using formula (2) i.e.

$$k = \frac{e}{\eta T\left(\frac{\Delta \ln I}{\Delta V}\right)}$$

6. Compare experimental value with the theoretical value. ($k = 1.38 \times 10^{-23}$ J/K)

Experiment No. 18

Photocell

Aim: To study the intensity response of photo cell and verify inverse squarelaw of radiations using a photoelectric cell.

Apparatus: Photo cell (Selenium) mounted in the metal box with connections brought out at terminals, Lamp holder with 60W bulb, two moving coil analog meters (500μA & 1000mV) mounted on the front panel and connections brought out at terminals, wooden bench fitted with scale and connecting wires.

Theory:

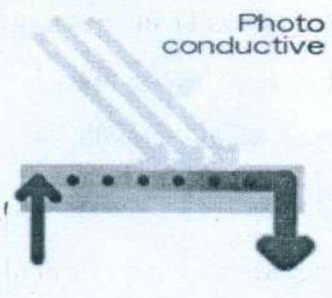
A device used to convert light energy into electrical energy is called Photo Electric Cell. Photocell is based on the phenomenon of Photoelectric effect. Photo cell are of three types.

1. Photo-Emissive Cell.
2. Photo-Voltaic Cell.
3. Photo-Conductive Cell.

In this experiment, photo-conductive cell is being used.

Photo-Conductive Cell:

Photo-Conductive Cell is also based on the principle of inner photoelectric effect. It consists of a thin film of semi-conductor like Selenium or Thallium sulphide placed below a thin film of semi-transparent metal. The combination is placed over the block of iron. The iron base and the transparent metal film is connected through battery and resistance. When light falls on the cell, its resistance decrease and hence the current starts flowing in the external circuit.



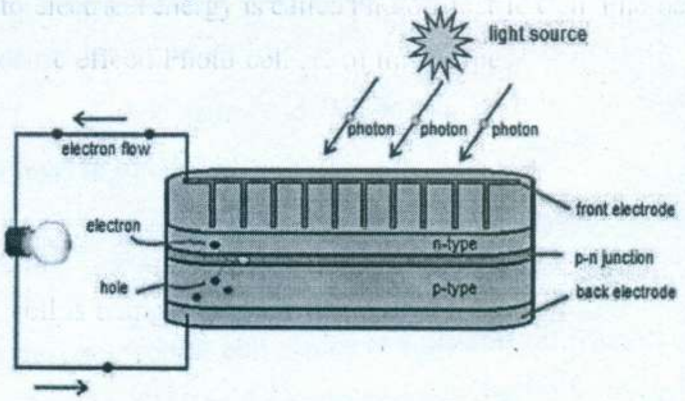


Fig. 3. Schematic and working of Photo conductive cell.

However here the change in current is not proportional to change in intensity of light. Further there also sufficient time lag between the change in light intensity and change in photo current so generated i.e. response time is large.

Selenium Cell: In this cell the base is Ni plated iron on which a thin layer of semiconducting

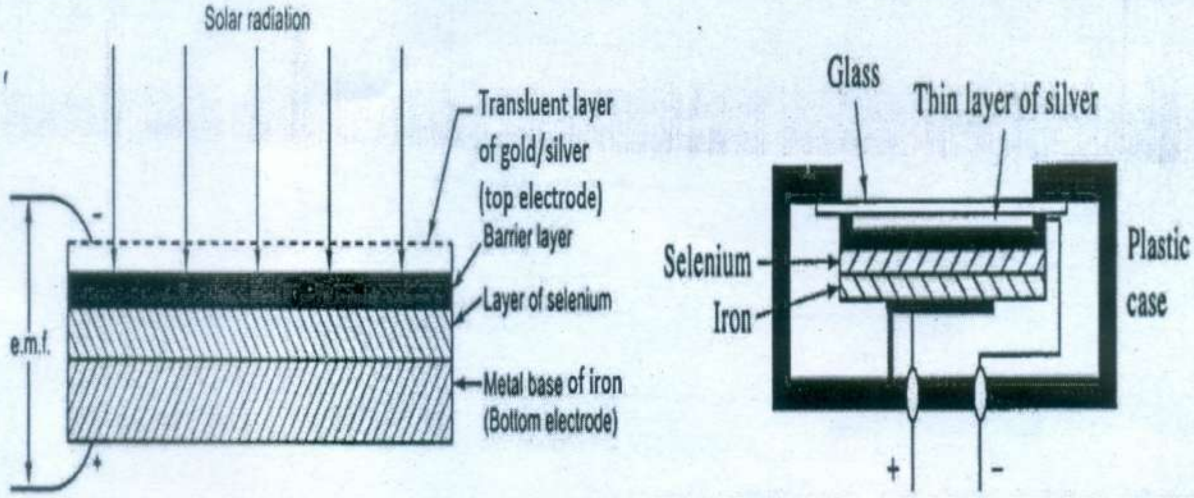


Fig.4. Selenium photovoltaic cell

material (e.g. Se) is spread. The surface is a translucent layer of Ag or Pt . The barrier layer is formed when silver is deposited by electrical sputtering process. A Cu ring is in contact with the iron bases serving as one electrode and óther Cu ring in contact with silver film acting as second electrode. The cell is enclosed in a case fitted with a protective window.

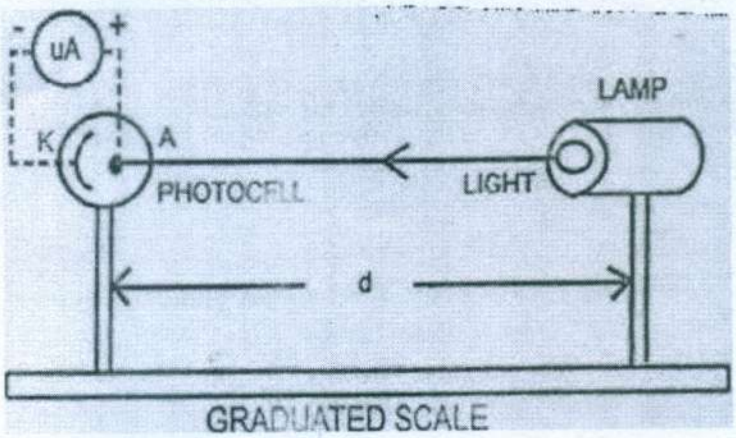
When light falls on the cell it passes through the window and incident on translucent surface film of silver and transparent barrier layer. On hitting the selenium layer it ejects electrons which move across the barrier. Under the influence of light a negative charge builds up on the silver electrode and positive charge on the bottom electrode producing an emf.

Let 'I' be the luminous intensity of an electric lamp and 'E' be the illuminance at a point distance'd' from it. According to the inverse square law;

$$E = \frac{I}{d^2}$$

If light from the lamp be incident on the photovoltaic cell placed at a distance'd' from it, then the photo-current given out is proportional to E and if θ be the corresponding deflection shown by the microammeter then, or $$\theta \propto \frac{I}{d^2}$$

or $$\theta \times d^2 = \text{constant}$$



Procedure:

1. Perform the experiment in dark room, for this mount the various parts of the apparatus on the wooden plank provided with a ½ meter scale. Make the other connections as shown in the Fig. 4.

2. Switch on the lamp and adjust it at a suitable distance from the photocell so that the micro ammeter and mill-voltmeter indicate a reasonable deflection.

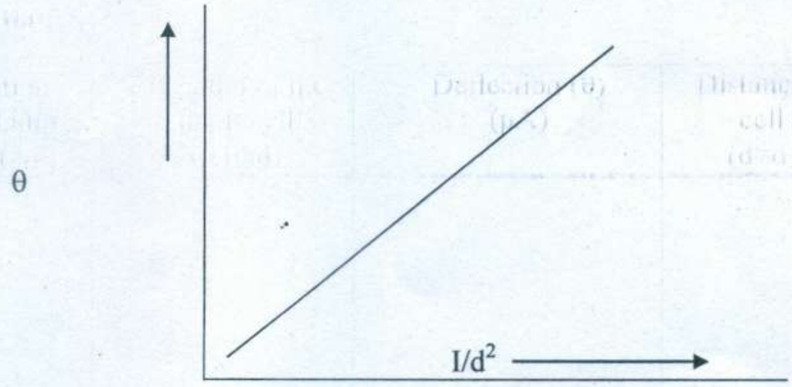
3. Change the distance of lamp from the voltaic cell and take a series of observations for the corresponding values of distance (d) and deflection (θ).

Observations:

S. No.	Position of the lamp d_1 (cm)	Position of the photocell d_2 (cm)	Deflection (θ) (μA)	Distance from Photo cell and lamp ($d=d_2-d_1$) (cm)	$1/d^2$ (cm^{-2})
1.					
2.					
3.					
4.					

Graph:

Plot a graph between $1/d^2$ and θ, taking $1/d^2$ along X-axis and θ along Y-axis. It should be astraight line.



Result: The intensity response of photo cell has been plotted in the graph. Since the graph between $1/d^2$ and θ is a straight line, hence it verify inverse squarelaw of radiations.

Precautions:

1. Stray light should be avoided.
2. The effect of the reflected light from the bench surface should be minimized.
3. Very sensitive micro ammeter should be used.

Some questions for viva voce examination:

Q.1 What is photoelectric effect?

Q.2 What is a photo cell?

Q.3 Define the illuminating power and intensity of illumination.

Q.4 Which type of the cell is a solar cell?

Q.5. Give two applications of solar cell in daily life.

Q6. Is there any difference between photodiode and photocell?

Instructions for Laboratory

- The objective of the laboratory is learning. The experiments are designed to illustr phenomena in different areas of Physics and to expose you to measuring instrumer Conduct the experiments with interest and an attitude of learning.

- You need to come well prepared for the experiment.

- Work quietly and carefully (the whole purpose of experimentation is to make reliat measurements!) and equally share the work with your partners.

- Be honest in recording and representing your data. Never make up readings or doct them to get a better fit for a graph. If a particular reading appears wrong repeat tl measurement carefully. In any event all the data recorded in the tables have to l faithfully displayed on the graph.

- All presentations of data, tables and graphs calculations should be neatly and carefull done.

- Bring necessary graph papers for each of experiment. Learn to optimize on usage c graph papers

- Graphs should be neatly drawn with pencil. Always label graphs and the axes and displa units.

- If you finish early, spend the remaining time to complete the calculations and drawin graphs. Come equipped with calculator, scales, pencils etc.

- Do not fiddle idly with apparatus. Handle instruments with care. Report any breakage tc the Instructor. Return all the equipment you have signed out for the purpose of youı experiment.

Phys

Instructions

1. Attend the Lab sessions in time

2. Don't forget to bring following accessories while attending the lab sessions

i. Lab manual

ii. I-Card

iii. Scientific Calculator

iv. Fully equipped compass box including 2-B Pencil, scale, sharpner and eraser

v. Plain journal papers

vi. Minimum three graph papers

3. Switch-off your cell phones when you are in the lab.

4. Bags should be kept on the racks. On lab tables keep only whatever is required for the experiment.

5. Handle the instruments with due care. Note that you are fully responsible for your apparatus in your lab session.

6. In case of electronic experiments, don't switch on the circuits unless checked by teacher or lab assistant. Operate multimeters with proper AC/DC settings & proper ranges.

7. Record all your lab work in the lab manual. Get it approved & signed by teacher.

8. All graphs are to be plotted in the lab itself. These can be directly attached in the journal

9. Complete your practicals in regular sessions only. Avoid extra practicals.

10. Complete your journals in time

11. Take care of your belongings