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ABES Engineering College, Ghaziabad (Autonomous)

DEPARTMENT OF APPLIED SCIENCES AND HUMANITIES

B.TECH. FIRST YEAR

PHYSICS LAB 25AS151/251

Laboratory Manual & Work Book

(For B.Tech I/II Semester Students)

Name...

Adm. No.............................Univ. Roll No.......................

Course................................ Branch.............................

Sem. _____________ Section ______________

ABES Engineering College, Ghaziabad

LIST OF EXPERIMENTS

1. To determine the energy band gap of a given semiconductor using p-n junction diode method.
2. Study of V-I characteristics of a diode.
3. To determine E.C.E. of copper using tangent galvanometer.
4. To verify Stefan's law by electrical method.
5. Measurement of wavelength of a laser light by using single slit diffraction.
6. To calibrate the given ammeter and voltmeter by potentiometer.
7. To study the V-I characteristics of a solar cell.
8. Determination of Numerical Aperture of an optical fiber.
9. To determine the bending losses of optical fibre.
10. To study the characteristics of a photodiode.
11. To determine Planck's constant using photo cell experiment.
12. To determine the specific rotation of cane sugar solution using Polarimeter.
13. To determine the wavelength of monochromatic light by Newton's Rings.
14. To determine the wavelength of spectral lines of mercury vapour lamp using plane transmission grating.
15. To study the variation of magnetic field along the axis of a current carrying coil and then to estimate the radius of the coil.

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10							

Teacher's Remarks (if any): **Average Marks:**

Name & Sign. of Faculty member(s) with date **Name & Sign. of Lab In charge** **HOD**

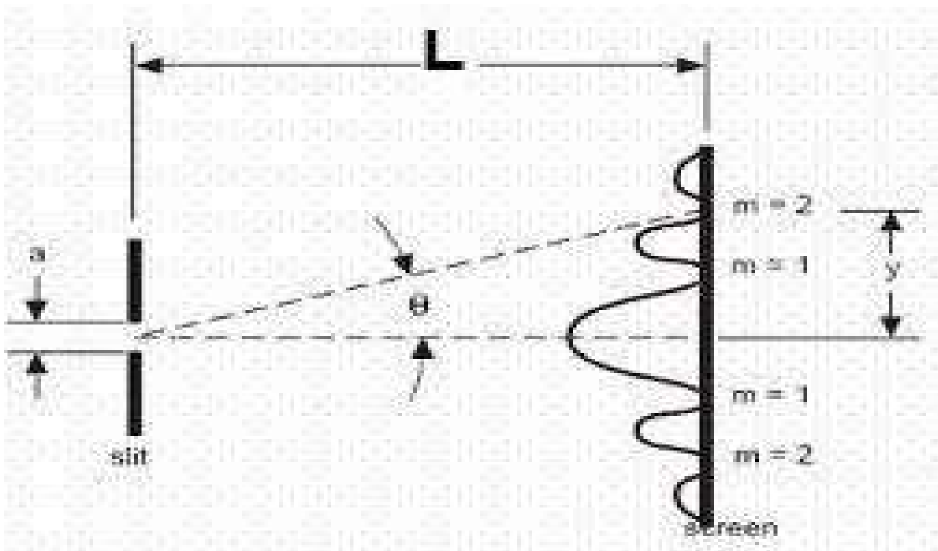
Date………. **Exp. No. …**

SINGLE SLIT DIFFRACTION

Aim: Measurement of wavelength of a laser light using single slit diffraction.

Apparatus Used: Diode laser, Single slit, screen, Optical Bench, measuring tape etc.

Theory and Formula used: Light has wave properties, and that two light waves of the same frequency can add up constructively (bright areas) or destructively (dark areas) depending on the path difference (the difference in distance from each light wave to the point where they meet) or their phase (the point in the wave cycle at a particular point in time – for instance, a wave described by the sine function leads a wave by the cosine by 90 degrees). Waves add up either when the original light wave is split up into two constituent waves (double slit interference) or when the same portions of the original light wave interfere with themselves (single slit or grating diffraction). The equations describing the position of the bright or dark spots on light coming out of a slit



projected upon a screen far away are summarized as follows:

$a \sin\theta = m\lambda$; $m = 1, 2, 3, \ldots\ldots\ldots\ldots$

$$\sin\theta = \frac{y}{\sqrt{y^2 + L^2}}$$

Here a is the width of the single slit, θ is the angular deflection (as measured from the central maxima, at which the path difference is zero and there is maximum addition of the two waves) of the dark areas (minima) on a screen far away, y is the distance between central maxima and the minima and L is the distance between screen and the slit. θ is the wavelength of the incoming light and m is the *order* of the minima – the higher order minima are farther from the central maxima; positive minima are to the right of the central maxima, while negative minima are to the left of the central maxima.

Procedure :

1) Place all the supplied parts (i.e. diode laser, slit holder & screen) on the optical bench in the sequence described above.
2) Place the Single Slit in the Slit holder.
3) Connect the Diode laser to AC Mains with help of the AC Adaptor supplied. Do not switch ON the laser as yet.
4) Adjust the level of the slit holder in the stand such that the laser, when switched ON, shall strikes at the halfway mark of the single slit.
5) Similarly place the screen (with graph paper) into its stand and keep it at a distance of about 1/2 meters from the single slit and adjust its height such that when the laser is switched ON, the diffraction pattern is obtained on the screen.
6) Switch on the laser & illuminate the single slit with the laser beam.
7) Make final adjustments such that the laser beam strikes the single slit and forms a diffraction pattern. Adjust the single slit so that the diffraction pattern formed is sharp & clear. Minor adjustment of the single slit shall result in rapid changes of the diffracted beam.
8) You should see a bright central band with several dimmer bands on each side. This is the single diffraction pattern.
9) Mark on the SCREEN, the locations of as many dark bands as you can easily see. Note that the central band is larger than the sidebands.
10) Measure the distance between the center of the dark bands on both sides of the central band and the distance from the slit to the SCREEN.
11) Choose, say, 2nd and 3rd minima and measure the separation between them accurately. Use the given formula to find the slit width.
12) Repeat the experiment with different readings of the distance of the screen from the slit.

Observation:

for a slit width (a) =.........................(cm)

S.No.	**L (cm)**	**y (cm)**	**m (order)**	**Sin θ**	**Wavelength (λ) in Å**
1.			**1**		
2.			**2**		
3.			**1**		
4.			**2**		

Calculations:

a sinθ = m λ ; m = 1, 2, 3, …………

$$\sin\theta = \frac{y}{\sqrt{y^2 + L^2}}$$

Calculated wavelength, λ = a sinθ / m

= ....Å

Standard wavelength of the source = 6500 Å

Result: The wavelength of given laser source is ....Å

Percentage error = (Standard wavelength ------ Calculated wavelength) / Standard wavelength X 100 %

Precautions and sources of error:

1. The laser should be aligned properly.
2. Scale and screen should be at appropriate distance

Faculty Sign…………………….. **Date: ………………….**

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ENERGY BAND GAP

Aim: To determine the band gap in a semiconductor using a PN junction diode.

Apparatus used: Power supply (DC-3 volts for Ge diode and DC-6 volts for Si diode), Microammeter, Electrical heat oven, Thermometer, Semiconductor diode, connecting wires etc.

Formula used: A graph is plotted between Log_{10} I_s and (10^3/T) that comes out to be a straight line. Its slope is found. I_s is the saturation current and T is the temperature of the sample.
Band gap, ΔE (in electron volts) is given by

ΔE = [(slope of the line)/5.036] eV

Theory:
In a semiconductor there is an energy gap between its conduction and valence band. For conduction of electricity a certain amount of energy is to be given to the electron so that it goes from the valence band to the conduction band. The energy so needed is the measure of the energy band gap, ΔE, between two bands.

When a P-N junction is reverse biased then current is due to minority carriers whose concentration is dependent on the energy gap, ΔE. The reverse current, I_s (saturated value) is a function of the temperature of the junction diode. For small range of temperature, the relation is expressed as
Log I_s = Constant – 5.036 ΔE (10^3/T)
Where temperature T is in Kelvin, ΔE is in electron volt.
A graph in Log_{10} I_s and (10^3/T) is plotted which comes out to be a straight line. The slope of this line will be 5.036 ΔE, giving the value of band gap for the semiconductor.

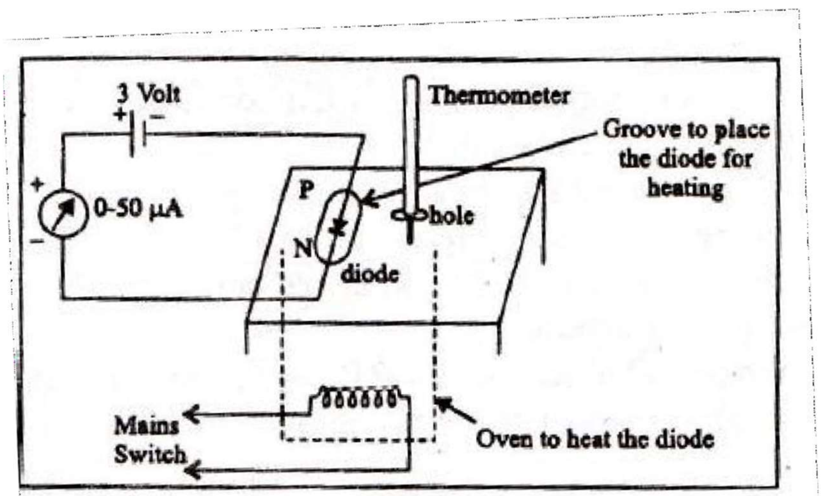

Fig. (1)

Procedure:

1. Connect P and N sides of junction diode to microammeter and power supply with polarity in reverse biased. Put the diode in place on the board for heating and fix a thermometer to measure the temperature.

2. Start heating by connecting oven‟s lead to mains and allow the oven temperature to increase upto 65°C.

3. As temperature reaches about 65°C, switch off the oven. The temperature will rise further say about 70°C and take current and temperature reading in step of 5°C rise in temperature.
4. Now temperature will begin to fall and again take current and temperature reading in step of 5°C fall in temperature.
5. Finally we take the average value of the current (i.e. increasing and decreasing).

Observations:
Least count of thermometer = Least
count of ammeter = Constant voltage
to diode =

S.No.	Current in Increasing (μA)	Current in Decreasing (μA)	Average Current (μA)	Temp. ^{0}C	Temp.0K	10^3/T (K)	Log I_s

Calculations: Plot a graph between $\text{Log}_{10} I_s$ and $(10^3/T)$ and find slope to obtain the

band gap, ΔE = [(slope of the line)/5.036] eV

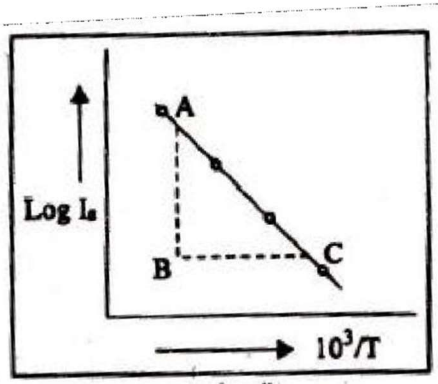

Fig. (2)

Result: Band gap for given (Ge) semiconductor = eV.

Standard results: ΔE = 0.67eV for Ge

Percentage error = %.

Brief discussion, if any:

Precautions and sources of error:

1. Maximum temperature should not exceed 80°C in case of Ge diode and 200°C in case of Si diode.

2. Silicon diode, if used, will require a maximum temperature of the order of 200°C. Therefore, oven and thermometer should be of this requirement.

3. Diode should be placed well within the oven so that it is in good contact of the heat of the oven.

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ECE OF COPPER

Aim: To determine the Electro – Chemical Equivalent (ECE) of copper using a Tangent galvanometer.

Apparatus used: Copper voltmeter, Tangent galvanometer, Rheostat, one way key, Battery, Commutater, Stop watch, Sand paper and connecting wire.

Formula used: Faraday‟s Law of Electrolysis

(i) According to first law mass deposited

$$m = Zit$$

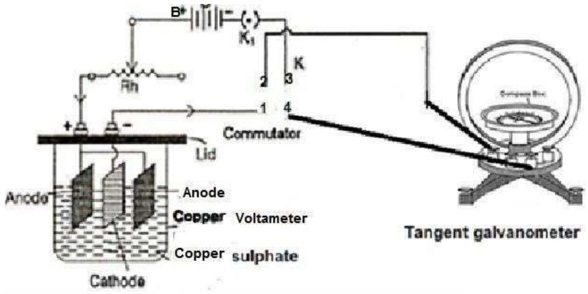
Where Z is constant and is called the Electro – Chemical Equivalent of the substance

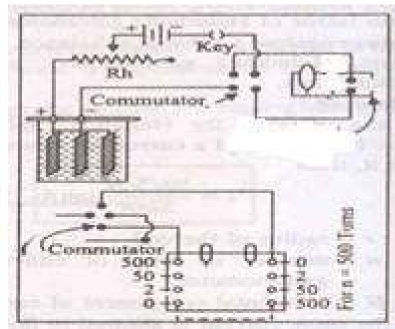
$$z = m/It$$

$$I = \frac{10rH\tan\theta}{2\pi n}$$

$$\boxed{z = \frac{2\pi nm}{10rH\tan\theta} \times \frac{1}{t}}$$

n= No. of turns in the coil.
m = Mass of copper deposited.
r = Radius of the coil.
H = Value of the earth‟s magnetic field.
t = Total time taken. (10 min for direct current and 10 min for reverse current).
Description of Apparatus and Circuit: Draw a neat diagram indicating the scheme of the connections as shown.





Procedure:

1. Clean the cathode plate with a piece of sand paper and weigh it accurately with the help of chemical balance.
2. **Adjustment of Tangent Galvanometer in the magnetic meridian**.
   Connect the circuit according to the circuit diagram without inserting the plug in the key K. Keep all the magnetic materials far away from the tangent galvanometer. Place the coil of T.G in magnetic meridian. For this setting, rotate the coil of the galvanometer in the horizontal plane of the coil, such that the magnetic needle and its image in the glass top of the galvanometer box all lie in the same vertical plane. Turn the compass box such that the pointer reads 0^0-0^0 line.
3. For more exact setting of the coil in the magnetic meridian, insert the plug in the key K_1 and pass the current in the coil and adjust its strength with Rh so as to get deflection of 45^0. Pass the current for 10 minutes.
4. Reverse the direction of current by means of commutator and note the deflection at the ends of the pointer. If it changes, maintain it constant by controlling the current with the help of rheostat Rh. Continue the process of copper deposition further for about 10 minutes.
5. Switch off the current.
6. Remove the copper plate, dry it and weigh it with chemical balance.

Observations:

Value of the field H	= ----- 0.345 Oersteds
Radius of the coil (r)	=--------------cm
Numbers of turns in each coil (n)	= 50
Mass of the copper plate before deposition of copper m_1	=--------------- gm
Mass of the copper plate after deposition of copper m_2	=----------------gm
Mass of copper deposited	=--------------- gm
Total time taken	=--------------- secs

Table for the determination of θ:

Time for current passage (mins)	Deflection of pointer for direct current		Deflection of pointer for reverse current		Mean (θ) $\frac{\theta 1+\theta 2+\theta 3+\theta 4}{4}$	Tan θ
	Left end of pointer θ_1	Right end of pointer θ_2	Left end of pointer θ_3	Right end of pointer θ_4		
0	45^0	45^0	45^0	45^0		
10						

Calculation:

Mass of copper deposited on copper plate = m_2 - m_1=------------------------gm

$$z = \frac{2\pi nm}{10rH\tan\theta} \times \frac{1}{t}$$

=...gms / coul

Result: The E.C.E of copper = -------------------------------------- gms / coulomb
Standard value of E.C.E of copper = 0.000329g / coulomb
%error=.....................

Precautions:

1. The coil should set in magnetic meridian.
2. All the magnetic materials and current carrying conductors should be at considerable distance from the apparatus.
3. The copper plate on which the deposit has to be made should be clean.
4. The deflection of the tangent galvanometer should be kept constant with help of rheostat.
5. As far as possible the deflection should be kept as nearly equal to 45^0 as possible since under this circumstance the accuracy in measurement is at a maximum.

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STUDY OF V-I CHARACTERISTICS OF A DIODE

Aim: To determine the VI characteristics of PN Diode

THEORY:

A diode is a PN junction formed by a layer of P type and layer of N type Semiconductors. Once formed the free electrons in the N region diffuse across the junction and combine with holes in P region and so a depletion Layer is developed. The depletion layer consists of ions, which acts like a barrier for diffusion of charged beyond a certain limit. The difference of potential across the depletion layer is called the barrier potential. At 2.5degree the barrier potential approximately equal 0.7v for silicon diode and 0.3v for germanium diode.

When the junction is forward bias, the majority carrier acquired sufficient energy to overcome the barrier and the diode conducts. When the junction is reverse biased the depletion layer widens and the barrier potential increases. Hence the Majority carrier cannot cross the junction and the diode does not conduct. But there will be a leakage current due to minority carrier. When diode is forward biased, resistance offered is zero, and when reverse biased resistance offered is infinity. It acts as a perfect switch.

PANEL DESCRIPTION.

The front panel houses four round meters (MO65) with their terminals brought out on the front panel for connections. For studying the forward bias

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characteristics, the two meters on the Right-hand side of the front panel are used. Out of these two meters, one is a voltmeter of approx. 0-1.5V range (depending upon the P-N junction diode used) & the other is a milliammeter of approx. 10mA range. For reverse bias characteristics of a zener diode, the two meters on the Left-hand side of the front panel are used. Out of these two meters one is a voltmeter of approx. 30V range & the other is a millimeter of 100□A range. Two P-N junction diodes are also mounted on the front panel, with their terminals brought out. The P-N junction diode mounted on the left hand side is used for studying the Reverse Bias Characteristics & one on the right is used for studying the Forward Bias Characteristics of the P-N junction diode.

Also provided on the front panel are 2 potentiometers or the voltage control knobs for the power supply.. The one marked "FORWARD BIAS" (placed on lower Right hand side of the panel) is used for studying the forward characteristics of a P-N junction diode (0-1.5V) & the other marked "REVERSE BIAS" (placed on the lower Left hand side of the panel) is used while studying the reverse bias characteristics of the P-N junction diode (0-30V).

S. No.	Forward Bias Voltage	Current in Forward Bias	Reverse Bias Voltage	Current in Reverse Bias

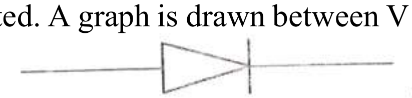
PROCEDURE:

FORWARD BIAS:

1. The connections are made as per the circuit diagram.
2. The positive terminal of power supply is connected to anode of the diode and negative terminal to cathode of the diode.
3. Forward voltage V_f across the diode is increased in small steps and the forward current is noted.
4. The readings are tabulated. A graph is drawn between V_f and I_f.

REVERSE BIAS:

1. The connections are made as per the circuit diagram.
2. The positive terminal of power supply is connected to cathode of the diode and negative terminal to anode of the diode.
3. Reverse voltage V_f across the diode is increased in small steps and the Reverse current is noted.
4. The readings are tabulated. A graph is drawn between V_r and I_r.



Circuit Symbol for P-N Junction Diode.

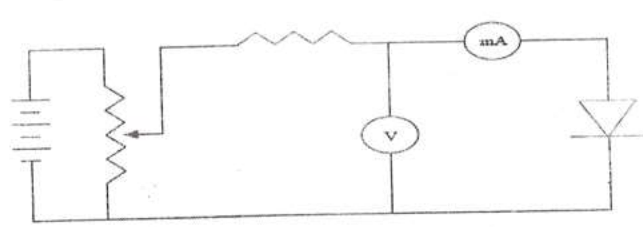


Fig 2. Diagram for Forward Bias

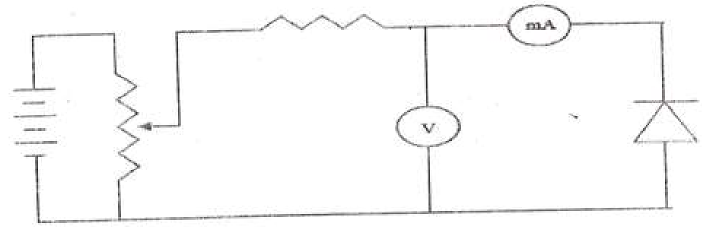
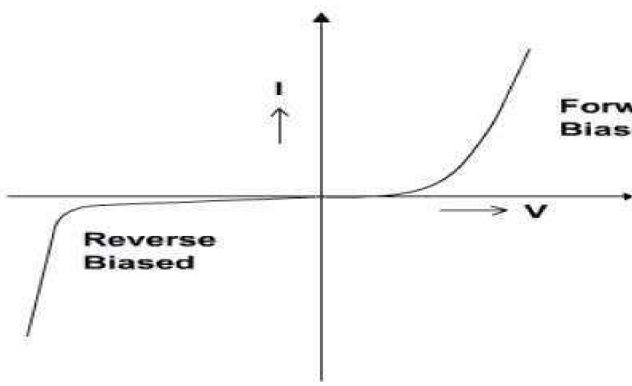


Fig 3. Diagram for Reverse Bias

MODEL GRAPH



Result : The forward bias and reverse bias characteristics curves are drawn for the given junction diode.

Precautions and sources of error:

1. In both the forward -- bias and reverse bias, the sliding contact of the rheostat should be kept to its minimum before switching on the power supply.
2. The reverse bias voltage should be kept below the breakdown voltage of the diode.
3. In forward bias mode the voltage should be increased in steps of 0.1 V and a milliammeter should read the current. In reverse bias mode the voltage should be increased in steps of 1 V and a microammeter should read the current.

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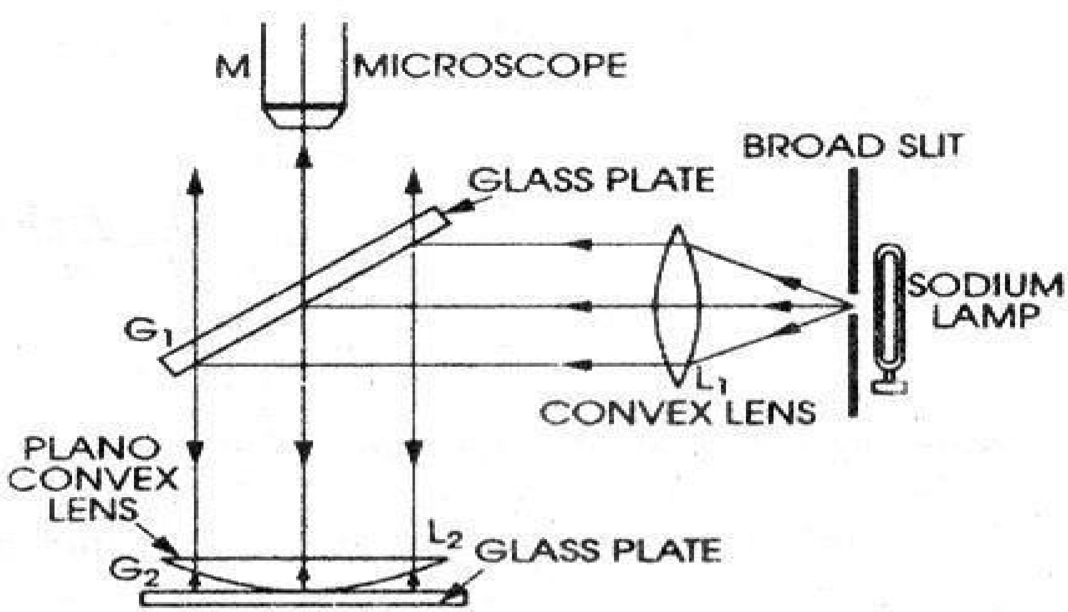
NEWTON'S RING

Aim: To determine the wavelength of sodium light with the help of Newton's rings setup.

Apparatus used: A plano-convex lens and plane glass plate arrangement, sodium lamp, travelling microscope, convex lens, eye piece, partly reflecting glass plate inclined at 45° and table lamp.

Ray diagram:



Formula used: Wavelength λ can be found by using formula

$$\boxed{\lambda = (D^2_{n+p} - D^2_{n})/ 4pR}$$

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

D_n= diameter of (n) th ring

P = an integer no. of ring

R = radius of curvature of the curved face of the plano- convex lens.

Procedure:

Measurement of ($D^2{}_{n+p}$ - $D^2{}_{n}$) / p:

1. The surface of both of glass plate and the plano - convex lens should first be cleaned smoothly with tissue paper.
2. The least count of the microscope is evaluated and recorded.
3. The microscope moved towards one side (say to the left of the central spot of certain numbers of dark and bright rings, say 12^{th} ring) and then allowed to move towards the right. As soon as the other wire which is perpendicular to the direction of motion of the microscope of the cross-wires becomes just tangential of the outer edge of 12^{th} dark or bright ring. The reading of microscope screw is noted. The motion of microscope towards the right is continued slowly by the circular screw and the readings of the screw are recorded every time the cross-wire becomes tangential to the outer edge of the every dark or bright rings (e.g. 12^{th} ,11^{th} ,10^{th}, etc.)

   On reaching the central spot portion the cross-wires are moved further to the other side of it and the readings of the screw recorded every time the cross-wire becomes tangential to the inner edge of the alternate dark or bright rings and 2^{nd},3^{rd}, etc till 12^{th} dark or bright ring is reached. Difference between the microscope readings on the outer edge on one side and inner edge another side of a ring will give its mean diameter D_n.

Observations:

[Note: There are three scales on travelling microscope 1. lengthwise scale, 2. width wise scale, 3. vertical scale, use lengthwise scale for measurement.**]**

For lengthwise scale:

Value of one division of the main scale **(MS)** = ……mm

Total No. of division on the vernier scale **(VS)** = …...

Least count of the scale **(LC)** = ……mm

The radius of curvature of given lens **R = ------------**cm

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Table for observing diameter 'D'of different rings

Ring No.	Crosswire on LHS of rings			Crosswire on RHS of rings			D_n= (a~b) (mm)	D^2_n (mm^2)	**$D^2_{n+p} - D^2_n$** (mm^2)	**p(any integer)**
	MS (mm)	VS	Total a = MS+(VS×LC) (mm)	MS (mm)	VS	Total b = MS+(VSxLC) (mm)				

Calculation: The wavelength of sodium light is calculated by substituting the given value of R and measured values of D^2_{n+p} - D^2_n and p in the following formula.

$$\lambda = (D^2_{n+p} - D^2_n)/ 4pR$$

λ=.....................

Result: From above measurements wavelength of sodium light found to be = ---------- (Å).

Standard result: The standard value of the wavelength of sodium light 5893(Å)

Percentage error: The percentage error is calculated by the following formula

$$\frac{\text{(Standard wavelength - Calculated wavelength)}}{\text{Standard wavelength}} \times 100\ \%$$

= …………. %

Sources of error and precautions:

(i) Glass plates and lens should be cleaned thoroughly.

(ii) Before measuring the diameter of rings, the range of the microscope should be properly adjusted.

(iii) Crosswire should be focused on a bright or dark ring tangentially.

(iv) Radius of curvature should be measured accurately.

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CALIBRATION OF VOLTMETER/AMMETER

Aim: Calibration of a Voltmeter with a potentiometer.

Apparatus used: Potentiometer, given voltmeter, two storage batteries, two rheostats, a standard cell, galvanometer, two one-way key, one two-way key and connection wires.

Formula used:

The error in voltmeter reading is given by

$$\mathbf{V' - V = (El_2/l_1) - V}$$

$$V' = kl_2,$$

Where: $E/l_1 = k$

V= potentiometer difference between two points read by voltmeter

V'= potentiometer difference between the same two points read by potentiometer

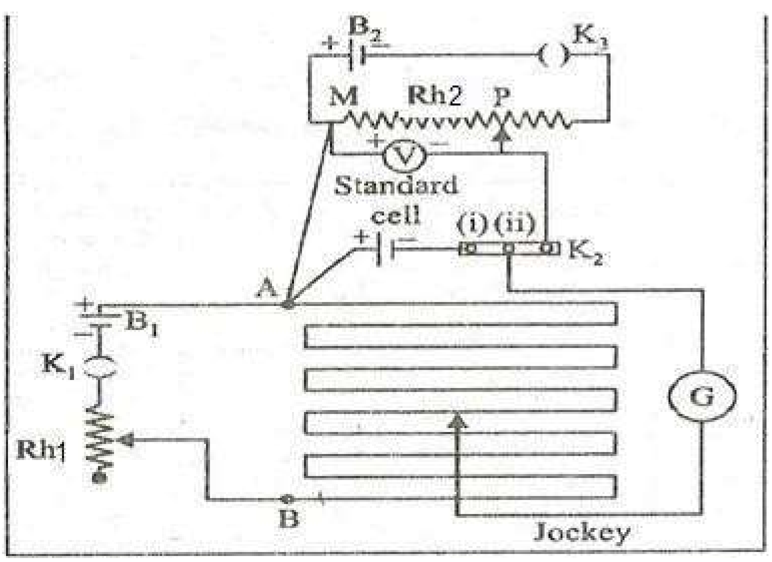
E= E.M.F. of the standard cell.

l_1 = length of the potentiometer wire corresponding to E.M.F. of standard cell.

l_2 = length of the potentiometer wire corresponding to the potential difference (V') measured by potentiometer.

k = potential gradient of the potentiometer wire

Electrical Connections:



Fig(1)

Procedure:

1. Make the electrical connections are show in fig (1).

2. Close K_1 and K_2 (i). Place the jockey on the last end „B‟ of the potentiometer wire. If the deflection is observed in the galvanometer, then the rheostat Rh_1 is adjust to get zero deflection (null point). The adjustment of the rheostat is not changed throughout the experiment.

3. Record the total balancing length (l_1) of the potentiometer wire. This is 1000cm for ten wire potentiometer. The EM.F. of the standard cell (E) is recorded.

4. Open K_2 (i) and close K_2 (ii). By closing K_3, adjust the variable point P of the potential divider such that the voltmeter reading may be 0.1 volt. Adjust the jockey on the wire such that there is no deflection in the galvanometer.

5. Note down the total length of potentiometer wire in this case (l_2).

6. Now repeat the above procedure again and again and record 6 different values of voltmeter reading V and corresponding values of l_2.

7. Now, plot a graph between the voltmeter reading (V) along the X-axis and the corresponding error in the reading (V'- V) along Y-axis. This is required calibration curve for the given voltmeter.

Observations:

Table 1: Table for the calibration of potentiometer wire:

Length of the Potentiometer wire Corresponding to EMF of standard cell, l_1 cm	**Remark**
1000	**EMF of standard cell E=.............volt** **Potential Gradient, k= E/l_1= …… volt/cm**

Table 2: Table for calibration of Voltmeter:

Sl. No	**Voltmeter Readings V volt**	**Balancing length of the potentiometer wire l_2**			**$V' = E\, l_2/l_1 = k\, l_2$**	**$(V' - V)$ volt**
		No. of complete wires	***Length on sliding wire**	**Total l_2 in cm**		
1						
2						
3						
4						
5						
6						

*** For even numbered wires (e.g. 2nd , 4th etc), the length should be read from the right end (End not connected with the battery).**

Calculations:

Potential Gradient $k = E/l_1$ = ……. volt/cm

Now $V' = E\, l_2/l_1 = kl_2$ = …… volt

Make similar calculation for other readings.

Draw a graph between the error (V' -V) and the voltmeter reading (V).

The shape will be zig zag.

Result:

The graph so obtained by plotting the error against the voltmeter reading is the calibration curve of the given voltmeter.

Precautions and sources of error:

1. The e.m.f. of the cell used in the primary circuit should be greater than the e.m.f of standard cell.

2. All the positive terminals should be connected to the same point of the potentiometer.

3. The calibration should be checked after few readings.

4. Jockey should not be moved on the potentiometer wire.

5. Voltmeter should be connected in parallel.

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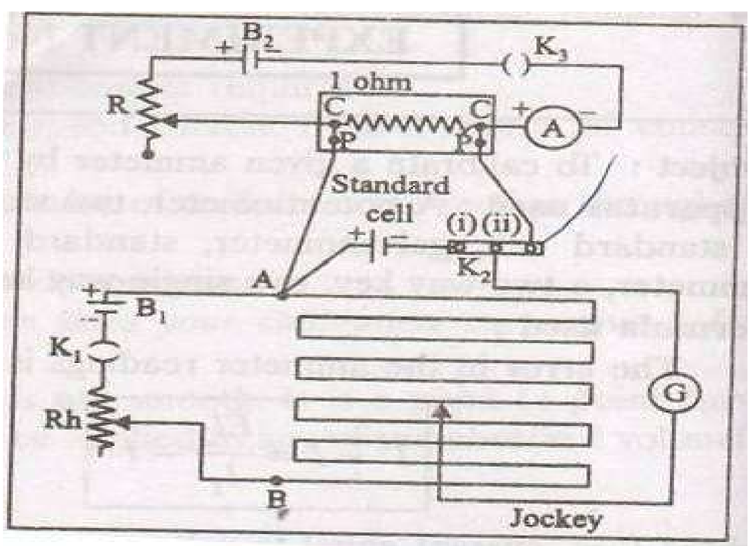
Aim: Calibration of a Ammeter with a potentiometer.

Apparatus used: Potentiometer, given voltmeter, two storage batteries, two rheostats, a standard cell, galvanometer, two one-way key, one two-way key and connection wires.

Formula used:
The error in voltmeter reading is given by
$I' - I = (El_2/l_1) - I$
$I' = kl_2,$
Where: $E/l_1 = k$
I= Current between two points read by voltmeter
I'= Current between the same two points read by potentiometer
E= E.M.F. of the standard cell.
l_1 = length of the potentiometer wire corresponding to E.M.F. of standard cell.
l_2 = length of the potentiometer wire corresponding to the potential difference (V') measured by potentiometer.
k = potential gradient of the potentiometer wire

Electrical Connections:



Fig(1)

Procedure:

1. Make the electrical connections are show in fig (1).

2. Close K_1 and K_2 (i) and place the jockey at point B. If the deflection is observed in the galvanometer, then the Rh_1 is adjust to get zero deflection (null point). The adjustment of the rheostat is not changed throughout the experiment.

3. Record the total balancing length (l_1) of the potentiometer wire. This is 1000cm for ten wire potentiometer. The EM.F. of the standard cell (E) is recorded.

4. Open K_2 (i) and close K_2 (ii). By closing K_2 (ii) and K_3 adjust the rheostat R such that the ammeter in the circuit records a current of 0.1 amp. Adjust the jockey on the wire such that there is no deflection in the galvanometer.

5. Note down the total length of potentiometer wire in this case (l_2).

6. By changing the current in the circuit with the help of rheostat R in steps, find out the total balancing length in each case.

7. Calculate the value of I" using formula

$$I` = \frac{E \times l_2}{l_1}$$

8. Now, plot a graph between the ammeter value along the X-axis and the corresponding error in the reading (I'- I) along Y-axis. This is the required calibration curve for the given voltmeter.

Observations:

Table 1: Table for the calibration of potentiometer wire:

Length of the Potentiometer wire Corresponding to EMF of standard cell, l_1 cm	**Remark**
1000	EMF of standard cell E= .... volt Potential Gradient, k= E/l_1= …… volt/cm

Table 2: Table for calibration of Ammeter:

Sl. No	Ammeter Readings I ampere	Balancing length of the potentiometer wire l_2			$I' = E\, l_2/l_1 = k\, l_2$	$(I' - I)$ volt
		No. of complete wires	*Length on sliding wire	Total l_2 in cm		
1						
2						
3						
4						
5						
6						

* For even numbered wires (e.g. 2nd , 4th etc), the length should be read from the right end (End not connected with the battery).

Calculations:

Potential Gradient $k = E/l_1 =$ ……. volt/cm

Now $I' = E\, l_2/l_1 = k l_2 =$ …… ampere

Make similar calculation for other readings.

Draw a graph between the error (I' -I) and the ammeter reading (I).

The shape will be zig zag.

Result:

The graph so obtained by plotting the error against the ammeter reading is the calibration curve of the given ammeter.

Precautions and sources of error:

1. The e.m.f. of the cell used in the primary circuit should be greater than the e.m.f of standard cell.
2. All the positive terminals should be connected to the same point of the potentiometer.
3. The calibration should be checked after few readings.
4. Jockey should not be moved on the potentiometer wire.
5. Voltmeter should be connected in parallel.

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VERIFICATION OF STEFAN'S LAW

Aim: Verification of Stefan's law

To verify **Stefans Law** of radiation (The law states that the amount of energy radiated through unit area in unit time from the surface of a perfect black body is directly proportional to the fourth power of its absolute temperature).

PRINCIPLE :-

The electric power dissipated from a bulb is taken to be proportional to the n^{th} power of the absolute temperature of its filament. The temperature of the filament in turn is directly proportional to its resistance. Hence, by measuring the resistance corresponding to different powers, **n** can be determined.

FORMULA :-

By ploting a graph taking **logP** along y-axis and **logR** along x-axis, the slope of the graph is calculated which gives n.

P = power dissipated from the bulb ($P = VI$)

R = resistance of the filament ($R = \frac{V}{I}$)

V = voltage across the bulb

I = current through the bulb

PROCEDURE :-

The circuit for verification of Stefans Law is rigged as follows :-

1. The patch cord provided with the training board are checked for continuity with the help of multimeter to make sure that there is no breakage in the connectors.
2. Using connecting leads Socket A is connected to C and B to D.
3. Milliammeter is connected across E and F. Voltmeter is connected across G and H.
4. J is connected to L and K to M.
5. The connections are checked once again and the apparatus is switched on.

6. Now the voltage is varied slowly, with the help of potentiometer, in steps of 0.5 volts and corresponding values of currents are noted (upto maximum of 3.8volts - otherwise the bulb may be damaged)

7. The power dissipated for each current and corresponding value of filament resistance are calculated using the relation $P = VI$ and

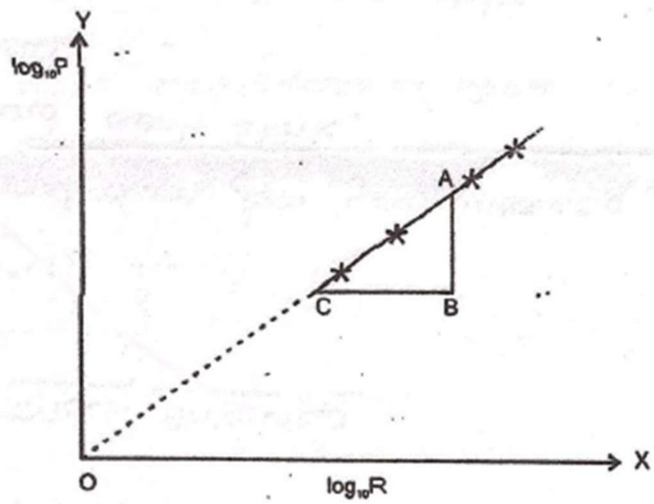
$$R = \frac{V}{I}$$

8. A graph is plotted by taking logP along y-axis and logR along the x-axis. The slope of the straight line graph is calculated which gives the value of n.

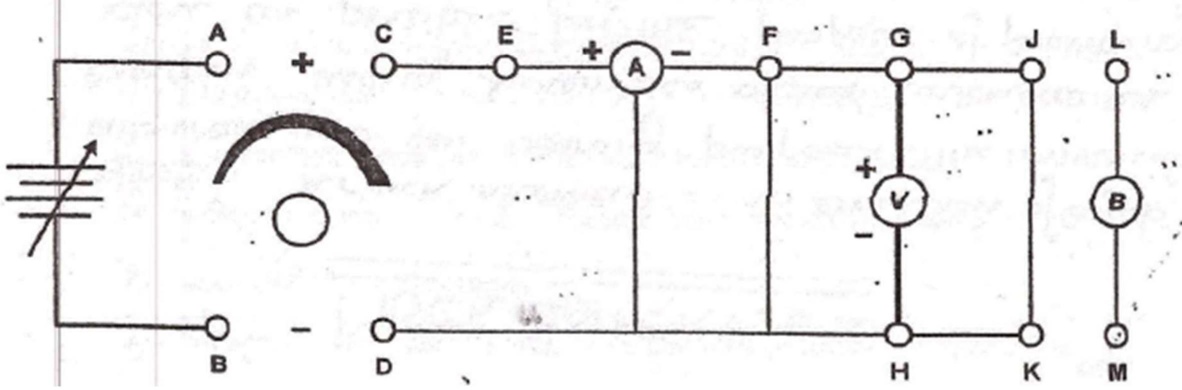
RESULT :-

The value of n = ...

Hence Stefan's Law is verified.



$$\text{Slope} = \frac{AB}{BC} = \text{.............} = n$$



S.No	Current Increasing			Power $P = VI$ (watt)	$\log_{10} P$	$\log_{10} R$
	V (Volt)	I (Amp)	R=V/I (ohms)			
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						

Graph:

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POLARIMETER

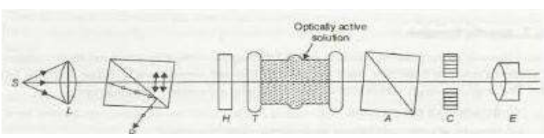
Aim: To find the specific rotation of cane-sugar solution by a polarimeter at room temperature, using Half shade polarimeter.

Apparatus used: Polarimeter set up, polarimeter tube, cane-sugar, physical balance, weight box, measuring cylinder, beaker and source of light.

Formula used: The specific rotation of cane- sugar solution is

$$S = \frac{\theta V}{lm}$$

Where θ = rotation of the plane of polarization (in sugar) produced by the solution
V = volume of the sugar solution in cc
l = length of the polarimeter tube in decimeter
m = mass (in gms.) of sugar dissolved in water



Procedure:

1. The polarimeter tube (T), is cleaned and filled with water such that no air is enclosed in it. If there remains a small air bubble, then the bubble is brought in the bubble trap while placing the tube inside the polarimeter.
2. The tube is placed in its position inside the polarimeter and the polarimeter is illuminated with monochromatic source(S).
3. Switch on the sodium lamp and focus the telescope at the position of equal brightness of both the halves by rotating analyser clockwise. Note down the position of analyzer on the circular scale (C).
4. Rotate the analyzer (A) in anti-clockwise direction for the same position of equal brightness. Note down readings of this position.
5. Now the polarimeter tube (T) is filled with sugar solution and repeat the same procedure as that for water. Note down readings with sugar solution of different concentation.

Observations:

Length of the polarimeter tube = 2 decimeter
Mass of sugar = 2 gms
Volume of the sugar solution = 50 ml

Concentrations of the solution : $C_1 = m/v = 2/50$ gms/ml = ……. gm/cc
$C_2 = m/2v = 2/100$ gms/ml = …… gm/cc

Least count of polarimeter (LC) =...........degree

Observation table for the angle of rotation:

S. No.	Analyzer reading with pure water						Conc. of sugar	Analyzer reading with sugar solution								Mean
	Clockwise			Anticlockwise				Clockwise			Anticlockwise			Θ_1	Θ_2	$\Theta = (\Theta_1 + \Theta_2)/2$
	M.S.	V.S.	TOTAL (a)	M.S.	V.S.	TOTAL (b)	C	M.S.	V.S.	TOTAL (c)	M.S.	V.S.	TOTAL (d)	a-c	b-d	
1																
2																

Calculations: Specific rotation,

$$S_1 = \frac{\theta_1}{lc} \quad \text{and } S_2 = \frac{\theta_2}{lc}$$

The specific rotation of cane sugar solution $S = \frac{S_1 + S_2}{2}$

Result: The specific rotation of cane sugar = --------------- degree/dm/gm/cc

Standard Result: The specific rotation of cane sugar= +66.7 degree/dm/gm/cc

Percentage error:

Sources of error and precautions:

(a) The polarimeter tube should be well cleaned.
(b) Water used should be dust free.
(c) There should be no air bubble inside the tube.
(d) The position of analyzer should be set accurately.

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DIFFRACTION GRATING

Aim: To determine the wavelength of prominent spectral lines of mercury light by a plane transmission grating.

Apparatus used: Mercury lamp, Spectrometer, diffraction grating and a reading lens, eye-piece, prism, spirit level, reading lens.

Formula used: The wavelength of any spectral line can be obtained from the formula.

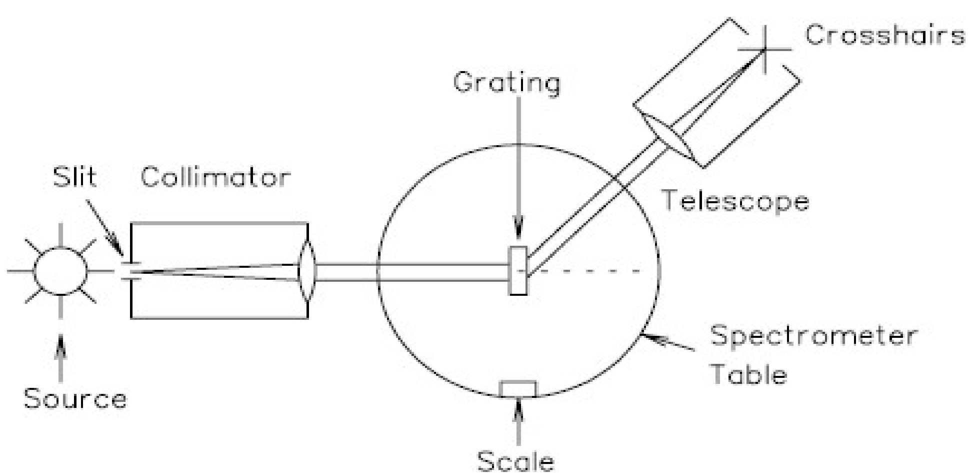
$$(e+d)\sin\theta = n\lambda$$

or, $$\lambda = \frac{(e+d)Sin\theta}{n}$$

Where, $e+d$ = Grating element

θ = Angle of diffraction

n = Order of spectrum



A) Adjustment of Spectrometer

The following adjustments should be done:

I) The optical axes of telescope and collimator should be perpendicular to the axis of rotation of the turn table and should meet at the same point.

This adjustment is done by the manufacturer.

II) Adjustment of the turn table:

1. The prism table is leveled with the help of three screws beneath the prism table. A spirit level is placed along the line joining the screws and the two screws are moved till the air bubble moves in the middle. Now place the spirit level along a line perpendicular to the previous line and adjust the third screw such that again the air bubble appears in the middle. Here one thing should be remembered that first two screws should not be touched this time. The prism table is now leveled.

III) Grating should be normal to the axis of collimator:

1. Collimator and telescope are arranged in a line and the image of the grating is focused on the vertical cross-wire.
2. The telescope is then rotated through 90^0 from this position.
3. The prism table is now rotated till the image of the slit, formed by reflection from the grating is thrown on the cross-wire.
4. The turn table is then rotated through 45^0 or 135^0 from this position. The plane of the grating thus be comes normal to the collimator axis.

After doing all the adjustments view the image of slit through telescope. Now remove the grating keeping eyes on eye-piece. Image of the slit should remain in the same place and should not shift in position.

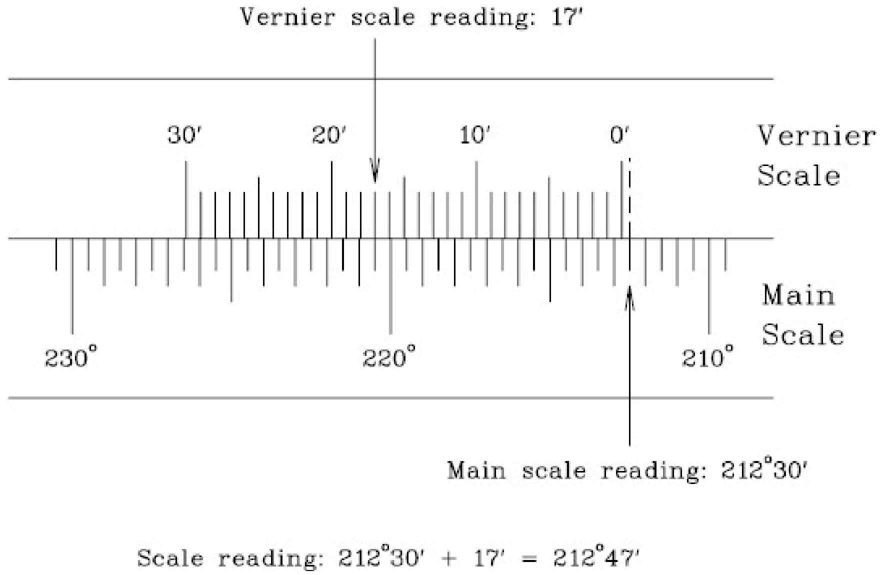
How to read the spectrometer readings:

Read the position of the telescope from the angular scale on the base. This can be done to a precision of 1‘‘ (±one minute, 60′= 1^0) . To read the scale:

1. Locate the "0" line on the vernier scale, and note which main scale division it is immediately after, e.g. 212^0 30‘‘ on the main scale. Note that the numbers on the main and vernier scales increase from right to left, and not from left to right as you are used to reading.

2. Scan along the line where the main and vernier scales meet, and note which one vernier scale division is directly in line with a main scale division, e.g. 17 on the vernier scale in Figure 5.

3. Add the main and vernier scale readings to obtain the angular scale reading, e.g. 212^0 30′ +17′= 212^0 47′ in Figure 5.



Procedure:

A. Readings for the angle of diffraction are taken as follows:

1) The telescope is rotated on one side (say left) of the direct image till red line of the first order spectrum comes on the cross wire (fig). The readings of both the verniers (V1 & V2) are recorded. Similarly, readings of both the verniers (V1 & V2) are recorded for other spectral lines (say violet and green).
2) Now rotate the telescope on the other side (say right) of the direct image and repeat the same procedure as above.
3) Find out the difference in readings of the same kind of verniers for each spectral line and calculate angle of diffraction (θ).

Observations:

(1) Observation for adjustment of the grating :
Least Count of the spectrometer = It is defined as the value of one division on main scale divide by total numbers of divisions on venire scale.

(2) Observations for the grating element:.
Grating element $(e + d) = \dfrac{2.54\ cm}{number\ of\ lines\ per\ inch}$

If the number of lines per inch on the grating = 15000.

$$(e + d) = 1.69 \times 10^{-4}\ \text{cm}$$

(3) Observations table for angle of diffraction (θ):

Order of Spectrum	Color of Spectrum	Reading for the Spectrum on				Value of 2θ			Mean Value of θ (deg)
		L.H.S.		R.H.S.		Vernier			
		V_1 (a) = MS+(VS ×LC)(deg)	V_2 (b) = MS+(VS ×LC)(deg)	V_1 (c) = MS+(VS ×LC) (deg)	V_2 (d) = MS+(VS ×LC) (deg)	V'_1 = a~c (deg)	V'_2 = b~d (deg)	Mean of 2θ = $(V'_1+V'_2)/2$ (deg)	
1^{st}	Violet								
	Green								
	Red								

Calculations:

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

Where n = order of spectrum

(e + d) = Grating element

Result: THE CALCULATED WAVELENGTH OF SPECTRAL LINES ARE AS BELOW:

Violet line λ_v =

Green Line λg =

Red Line λ_r =

Standard values:

Violet line λ_v **= 380-450 nm Green line** λg **= 495-570 nm Red Line** λ_r **= 620-750 nm**

Percentage error: $$\frac{(\text{Standard value} - \text{Observed value})}{\text{Standard value}} \times 100$$

Precautions:

1. The grating should not be touched with hand or rubbed. It should always be held by means of fingers kept on the opposite edges of the grating.
2. Grating should be perfectly normal to the axis of the collimator.
3. The turn – table must be leveled optically.
4. While recording observations the telescope should be rotated in the same direction in order to avoid backlash error.
5. The slit should be as narrow as possible.
6. All the preliminary adjustments of the spectrometer must be made before starting the experiment.
7. While taking observations the turn table must remain clamped.
8. Both verniers should be read.

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AXIAL MAGNETIC FIELD

Aim: To study the variation of magnetic field with distance along the axis of a circular coil carrying current.

Apparatus: Circular coil, compass box, ammeter, rheostat, commutator, cell, key, connection wires, etc.

The purpose of the commutator is to allow the current to be reversed only in the coil, while flowing in the same direction in the rest of the circuit.

Formula Used: The intensity relation is expressed as

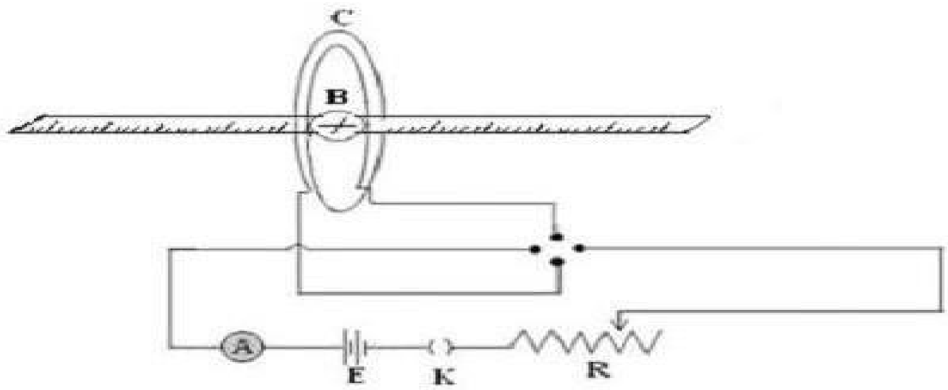
$$F = \frac{2\pi n r^2 i}{10(x^2 + r^2)^{3/2}}$$

Where n = number of turns in the coil
r = radius of the coil
i = current flowing in the coil (in ampere)
x = distance of the point from the center of the coil.

If F is made perpendicular to H, earth‟s horizontal field, the deflection θ of the needle is given by

$$F = H\tan\theta = \frac{2\pi n r^2 i}{10(x^2 + r^2)^{3/2}}$$

Figure: Experimental setup



C – circular coil

A – ammeter

B – Compass box

E - Cell

R - rheostat

Procedure:

The connections are made as shown in the diagram and the initial adjustments of the apparatus are made as follows:

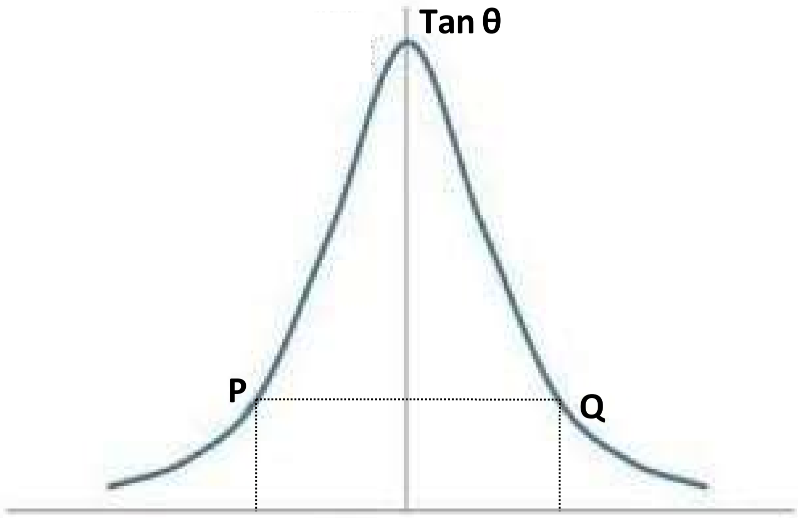
1. First, the coil is fixed at the middle of the platform and the compass box is placed at the center of the coil.
2. The apparatus is rotated such that coil, needle and it's image all lie in same vertical plane.
3. Then the compass box as a whole is rotated till pointer reads 0-0.
4. Close the circuit.
5. Adjust the rheostat until the deflection lies at 75 degrees. Note down the deflection of the compass needle and the current.
6. Then current through the coil is reversed using the commutator and again the deflection and current are noted.
7. Average the magnitude of the two deflections and calculate the magnetic field at the center of the coil from the equation.
8. Without changing the current or the number of turns, place the compass box at a particular distance from the center of the coil. Note the deflection. Again, reverse the current and average the magnitudes of the two deflections. Note the average, and the distance.
9. The same procedure is repeated with the compass box at the same distance on the other side of the arm, keeping number of turns and current constant.
10. Take the average of the two values of θ measured on opposite sides of the coil.
11. Then calculate the magnetic field B_x from the coil using equation (3).
12. Repeat for various distances.
13. Draw graph of B_x on the vertical axis *vs*. distance x on the horizontal axis.

Observation Table:

To plot the graph between distance and magnetic field intensity:

S. No.	Distance of the needle from the center, x (cm)	Deflection on East Arm					Tan θ	Deflection on West Arm					Tan θ
		Current one way		Current reversed		θ (degree)		Current one way		Current reversed		θ (degree)	
		θ1	θ2	θ3	θ4			θ1	θ2	θ3	θ4		
1	0												
2	2												
3	4												
4	6												
5	8												
6	10												
7	12												
8	14												
9	16												

Graph showing variation of magnetic field along the axis of the circular coil.



distance, x (cm)

Result: The graph shows the variation of magnetic field along the axis of a circular coil carrying current. The distance between the points of inflexion P,Q and hence the radius of coil (PQ) = ….cm.

Precautions:

1. The coil should be carefully adjusted in magnetic meridian.
2. There should not be any kind of magnetic or current carrying substance/device nearby experimental setup.
3. Parallax should be removed while reading the position of the pointer and both ends of the pointer should be read.The curve should be drawn smoothly.

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