



MINING ENGINEERING
LAB MANUAL

PHYSICS LAB
(B.TECH)

SEMESTER I

Semester: First
Course: Physics I
Course Code: 8BSC101P

L	T	P	C
0	0	3	1.5

List of Laboratory Experiments/Demonstrations:

1. Find the acceleration due to gravity using Kater's pendulum.
2. Find the resistance of a given wire using Meter Bridge.
3. To establish the current voltage relationship for a metallic conductor and find its resistance.
4. To determine the unknown resistance of given wire using Potentiometer.
5. Find the acceleration due to gravity using Simple pendulum.
6. To determine Young's modulus of the material of a given wire using Searle's Apparatus
7. To determine the unknown resistance of given wire using Potentiometer.
8. To determine the wavelength of sodium light by Newton's ring method.
9. To measure the wavelength of Mercury spectrum using Spectrometer grating.
10. To study the variation of magnetic field with distances using Helmholtz Galvanometer.

CONTENT

Sr. No	Name of Experiments	Page no
1.	Find the resistance of a given wire using Meter Bridge	4
2.	To establish the current voltage relationship for a metallic conductor and find its resistance.	8
3.	Find the acceleration due to gravity using Simple pendulum.	11
4.	Find the acceleration due to gravity using Kater's pendulum.	13
5.	Compare the e.m.f of two primary cells using Potentiometer	16
6.	Determine the elastic constants of the material of a wire using Searle's Method.	20
7.	P-N Junction Diode characteristics	23
8.	To determine the wavelength of sodium light by Newton's ring method.	28
9.	To measure the wavelength of Mercury spectrum using Spectrometer grating.	32
10.	To study the variation of magnetic field with distances using Helmholtz Galvanometer.	37

EXPERIMENT NO: 1

Meter Bridge

OBJECTIVE: To find the resistance of a given wire using a metre bridge and hence determine the specific resistance of its materials.

APPARATUS: A meter bridge, galvanometer, one way key, a resistance box, a battery jockey, unknown resistance wire about 1 meter long, screw gauge and connecting wires.

THEORY:

A meter bridge is the practical application of Wheatstone bridge arrangement as shown in figure below. The four resistances are connected to each other as shown and if the bridge is in balanced state, i.e., there is no deflection in the galvanometer (G),

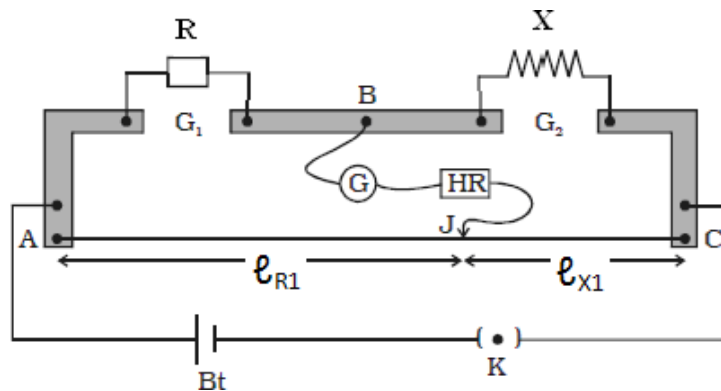
$$P/Q = R/S$$

Resistance of the wire $X = R \frac{l_X}{l_R}$

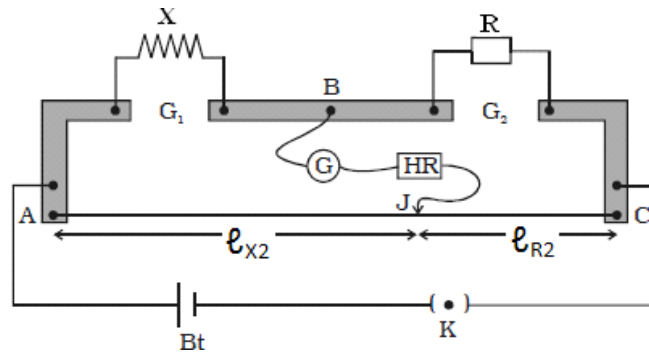
Specific resistance of the material of the wire $\rho = \frac{\pi r^2 X}{l}$

- Where
- R is known resistance
 - l_R is the balancing length of R
 - l_X is the balancing length of X
 - r is the radius of the wire
 - l is the length of the wire

Circuit diagram – Before interchanging



Circuit diagram – After interchanging



PROCEDURE

The connections are made as in the circuit diagram. The jockey J is pressed near the ends A and C and if the deflections in the galvanometer are in the opposite directions, then the circuit is correct. Now the jockey is moved over the wire and its position J is found when there is no deflection in the galvanometer. The balancing length $AJ = \ell_{R1}$ is measured. $JC = \ell_{X1}$ is found out as $(100 - \ell_{R1})$.

The experiment is repeated four more times by increasing the value of R in steps of 1 ohm.

Then the resistance box R and coil X are interchanged in the gaps G_1 and G_2 . For the same values of R as in the previous part of the experiment the balancing length $AJ = \ell_{X2}$

are measured. The balancing length $JC = \ell_{R2}$ are found out as $(100 - \ell_{X2})$. The values of ℓ_X and ℓ_R are calculated from

$$\ell_X = \frac{\ell_{X1} + \ell_{X2}}{2} \quad \ell_R = \frac{\ell_{R1} + \ell_{R2}}{2}$$

The resistance of the coil is found by substituting in the formula

The length (ℓ) of the coil is measured using scale and radius(r) of the coil is measured using

screw gauge. The specific resistance of the coil is calculated using the formula

$$\rho = \frac{\pi r^2 X}{\ell}$$

OBSERVATION

- To determine the resistance of the given coil

S. No	R (ohm)	Balancing length before interchanging		Balancing length after interchanging		Mean		$X = R \frac{l_X}{l_R}$ (ohm)
		l_{X1} (cm)	l_{R1} (cm)	l_{X2} (cm)	l_{R2} (cm)	$l_X = \frac{l_{X1} + l_{X2}}{2}$ (cm)	$l_R = \frac{l_{R1} + l_{R2}}{2}$ (cm)	
1	1							
2	2							
3	3							
4	4							
5	5							

- To determine the radius of the coil

LC = $0.01 \times 10^{-3}m$

ZERO ERROR =

ZERO CORRECTION =

S.No	PSR	HSC	HSR	CR = PSR+HSR×L.C
1				
2				
3				
4				
			Diameter 2r	
			r	

Mean X =

RESULT:

Resistance of the wire X = ----- Ω

Specific resistance of the material of the wire ρ = ----- Ωm

PRECAUTIONS:

1. All the connections should be correct and tight.
2. Only small amount of resistance will be applied through the resistance box.
3. The Jockey should be sliding over the entire wire steadily and not be connected for long.
4. Switch off the power supply when experiment is over.

EXPERIMENT No- 2

To establish the current voltage relationship for a metallic conductor and find its resistance.

Verification of Ohm's law.

OBJECTIVE: Verification of Ohm's law.

EQUIPMENT REQUIRED: - Accumulator or battery eliminator, ammeter, voltmeter, rheostat, Coil, connecting wires and key (if necessary).

THEORY:-

Ohm's Law deals with the relationship between voltage and current in an ideal conductor. This relationship states that: The potential difference (voltage) across an ideal conductor is proportional to the current through

it. The constant of proportionality is called the "resistance", R.

Ohm's Law is given by:

$$\mathbf{V=IR}$$

Where V is the potential difference between two points which include a resistance R.

I is the current flowing through the resistance.

Or

Ohm's law states that the current through a conductor between two points is directly proportional to the voltage across the two points, and inversely proportional to the resistance between them.

V, I, and R, the parameters of Ohm's law.

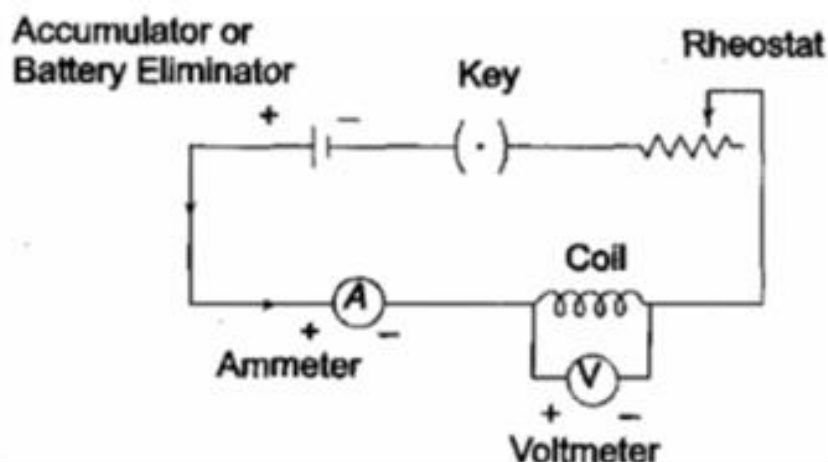
$$\mathbf{I=V/R}$$

Ohm's law is among the most fundamental relationships in electrical engineering. It relates the current, voltage, and resistance for a circuit element so that if we know two of the three quantities we can determine the third. Thus, if we measure the current flowing in a resistor of known value, we can deduce the voltage across the resistance according to $V = IR$. Similarly, if we measure the voltage across a resistor and the current through it, we calculate the resistance of the element to be

$$\mathbf{R = V/I.}$$

Not only does this reduce the number of measurements that must be made, it also provides a way to check the results of several different measurement methods.

CIRCUIT DIAGRAM:



PROCEDURE:-

- Connect the battery eliminator, ammeter, the given coil, rheostat and key (if necessary) in series.
- The voltmeter is connected in parallel connection across the given coil. The circuit is closed.
- Now the rheostat is adjusted so that a constant current flows through the coil. Note down the ammeter reading I and the corresponding potential difference across the coil in the voltmeter as V .
- Use the formula to calculate the resistance of the coil.
- The experiment is repeated for different values of current and the corresponding potential difference is noted. Calculate the value in each trial.
- These values will be found to be a constant. Thus verifying Ohm's law.

OBSERVATION TABLE:

Serial No	Ammeter reading I (ampere)	Voltmeter reading V (volt)	Resistance of coil $R = V/I$ (OHM)

RESULT:-

By observing the observation table, it is proved that the ratio of potential difference and current is constant. Thus, potential difference at the ends of the conductor is directly proportional to the current flowing through it. Thus, ohm's law is verified by this experiment.

PRECAUTIONS: -

All the connection should be tight.

Ammeter is always connected in series in the circuit while voltmeter is parallel to the conductor.

The electrical current should not flow the circuit for long time, otherwise its temperature will increase and the result will be affected.

Maximum reading of voltmeter should be greater than the electromotive force of the cell.

It should be care that the values of the components of the circuit is does not exceed to their ratings (maximum value).

Before the circuit connection it should be check out working condition of all the components.

EXPERIMENT NO: 3

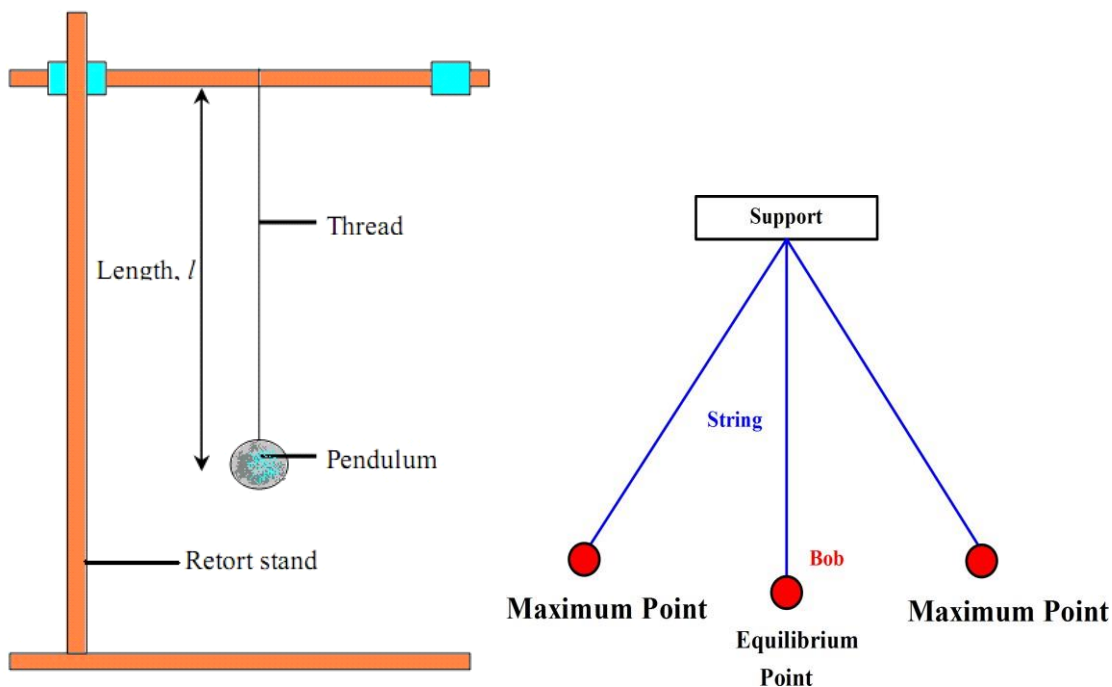
Measurement of g : Use of a simple pendulum

OBJECTIVE: To measure the acceleration due to gravity using a simple pendulum.

INTRODUCTION:

Many things in nature wiggle in a periodic fashion. That is, they vibrate. One such example is a simple pendulum. If we suspend a mass at the end of a piece of string, we have a simple pendulum. Here, the to and fro motion represents a periodic motion used in times past to control the motion of grandfather and cuckoo clocks. Such oscillatory motion is called *simple harmonic motion*. It was Galileo who first observed that the time a pendulum takes to swing back and forth through small distances depends only on the *length of the pendulum*. The time of this to and fro motion, called the **period**, does not depend on the mass of the pendulum or on the size of the arc through which it swings. Another factor involved in the period of motion is, the acceleration due to gravity (g), which on the earth is 9.8 m/s^2 . It follows then that a long pendulum has a greater period than a shorter pendulum.

PROCEDURE:



The period T of a simple pendulum (measured in seconds) is given by the formula:

$T = 2\pi \sqrt{L/g}$	(1)
-----------------------	-----

T = time for 30 oscillations	(2)
30 oscillations	

using equation (1) to solve for “g”, L is the length of the pendulum (measured in meters) and g is the acceleration due to gravity (measured in meters/sec²). Now with a bit of algebraic rearranging, we may solve Eq. (1) for the acceleration due to gravity g. (You should derive this result on your own).

$g = 4\pi^2 L/T^2$	(3)
--------------------	-----

- Measure the length of the pendulum to the middle of the pendulum bob. Record the length of the pendulum in the table below.
- With the help of a lab partner, set the pendulum in motion until it completes 30 to and fro oscillations, taking care to record this time. Then the period T for **one** oscillation is just the number recorded divided by 30 using (eq. 2).
- You will make a total of eight measurements for g using two different masses at four different values for the length L.

Note: $\pi = 3.14$, $4\pi^2 = 39.44$

OBSERVATION TABLE:

Sr. no	L (meters)	mass	Time for 30 oscillations	Period T (seconds)	T ²	g = 39.44L/T ²

Average value of g = _____

EXPERIMENT NO: 4

Measurement of g: Use of a Kater's Pendulum

OBJECT:- To determine the value of acceleration due to gravity with Kater's pendulum.

APPARATUS:- Kater's pendulum, a stop watch and a meter rod.

FORMULA:-

The following formula is used for the determination of acceleration due to gravity 'g':

$$g = \frac{8\pi^2}{\frac{T_1^2 + T_2^2}{l_1 + l_2} + \frac{T_1^2 - T_2^2}{l_1 - l_2}} \quad \text{----- (1)}$$

Here, T1: time periods of the oscillating pendulum from knife-edge K1

T2: time periods of the oscillating pendulum from knife-edge K2

l1: distances between knife-edges K1 and CG of the pendulum

l2: distances between knife-edges K2 and CG of the pendulum

When T1 and T2 are very close to each other (difference less than 1 percent), the above expression becomes as:

$$g = \frac{8\pi^2}{\frac{T_1^2 + T_2^2}{l_1 + l_2}} \quad \text{----- (2)}$$

PROCEDURE:

- Fix the weights as shown in the figure.
- Make sure that the distances from big masses to ends and big masses to knife edges should be symmetrical.
- Balance the pendulum on a sharp wedge such that the smaller weights are at symmetrical distance from CG. Now mark the position of its centre of gravity and measure the distance of the knife-edges K1 and K2 CG. This will give you the values of l_1 & l_2 .
- Suspend the pendulum with the knife-edge K1 and set it to oscillate with small amplitude. Note the times for 15, 20 and 25 oscillations respectively.
- Now suspend the pendulum with the knife-edge K2 and set it to oscillate with

small amplitude. Note the times for 15, 20 and 25 oscillations respectively.

- The oscillations should be seen with the help of a telescope for accuracy.

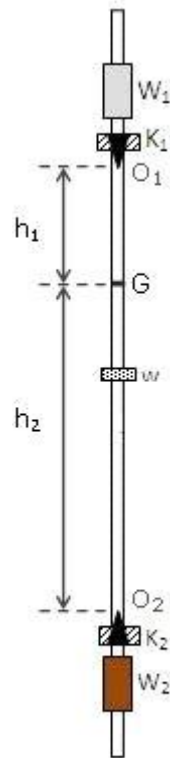


Figure 1

OBSERVATION:

1. Least count of stop watch =sec
2. Distance between K1 and CG (l1) = cm
3. Distance between K2 and CG (l2) = cm
4. Table for time period T1 (oscillation about K1):
5. Table for time period T2 (oscillation about k2) :

<i>Sr. No.</i>	<i>Number of Oscillation</i> <i>n</i>	<i>Time of Oscillation</i> <i>t₁(sec)</i>	<i>Time Period</i> <i>T₁=t₁/n</i>	<i>Mean</i> <i>T₁</i> <i>(sec)</i>
1.	15			
2.	20			
3.	25			

Sr. No	No of oscillations N	Time of oscillation T ₂ (Sec)	Time period T ₂ = t ₂ /N	Mean T ₂ (Sec)
1.	15			
2.	20			
3.	25			

CALCULATION:

Using equation (1) or (2) {depending on value of T₁ and T₂} calculate the value of g.

RESULT:

The Acceleration due to gravity g =----- m/s².

Standard value of g = 9.8 m/s²

PERCENTAGE ERROR: $(\Delta g / g) \times 100\%$

PRECAUTIONS:

1. The two knife-edges should be parallel to each other.
2. The amplitude of vibration should be small so that the motion of the pendulum satisfies the condition of simple harmonic motion.
3. To avoid any irregularity of motion the time period should be noted after the pendulum has made a few oscillation.
4. To avoid friction there should be glass surface on rigid support.

EXPERIMENT NO: 5

To Compare the EMF of Two Given Primary Cells Using Potentiometer

AIM & OBJECTIVE:

To set up a potentiometer and use it to compare the EMF of two given primary cells using potentiometer.

APPARATUS:

Potentiometer, Leclanche cell, Daniel cell, Two way key, Resistance box plug type (0 to 1000 Ω), Galvanometer, Voltmeter, Battery eliminator, Low resistance rheostat, Two one-way keys, Connecting wires, Sandpaper

Theory

The device works on the principle that when two points are at the same potential, no current flows through the wire connecting those points. To use the device, a potential is set across the wire of the potentiometer. Each unit length of the potentiometer has a certain potential, known as the potential gradient. It can mathematically be expressed as Potential gradient = Potential across potentiometer wire / Total length of potentiometer wire. When the jockey connected to one end of the cell of unknown EMF is slid over the potentiometer wire, it tries to balance the EMF of the cell with the potential of the wire. As soon as the length of the potentiometer to suffice the EMF of the cell is reached, the galvanometer shows no deflection. Thus the null point is said to be obtained.

Mathematically, the EMF of cell (E) and the length of potentiometer wire (L) can be related as

$$E = k \times L .$$

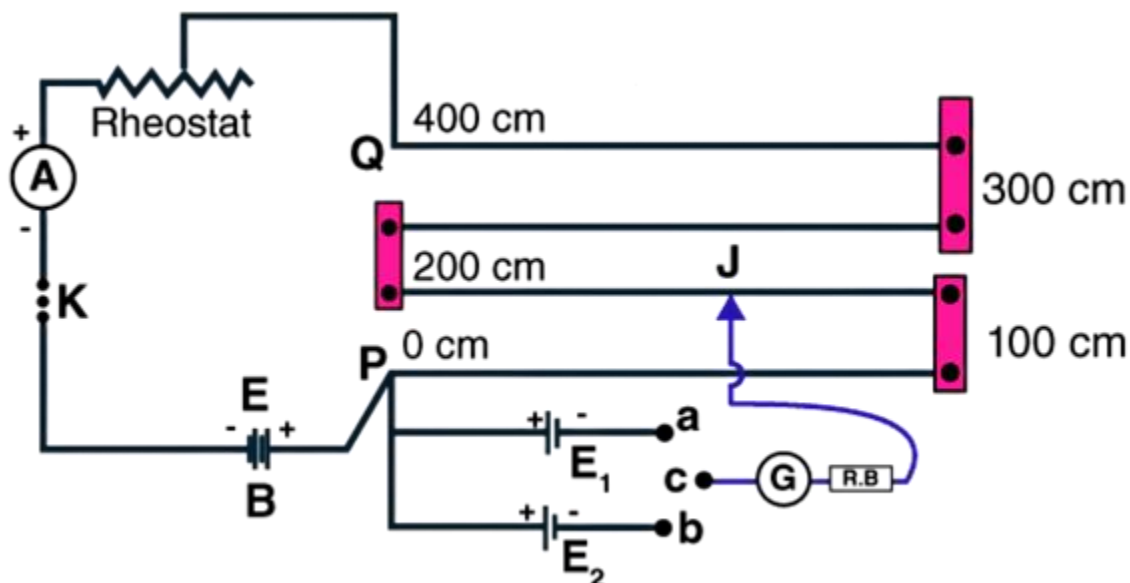
Where k is the potential gradient of the potentiometer wire.

Therefore, to compare the EMF of two different cells, the ratio of their EMF can be calculated as the ratio of the lengths of their null points as

$$\frac{E_1}{E_2} = \frac{L_1}{L_2}$$

Procedure

1. Connect the circuit as shown in the potentiometer diagram. In the diagram, E_1 and E_2 are two cells of unknown EMF, and E is the cell providing potential difference to the potentiometer circuit. The negative terminal of cell E is connected to the end B of the potentiometer wire through a one-way key K_1 and a rheostat.



Circuit diagram

2. A two-way key is attached to the negative terminals of the unknown cells- a and b denote the two keys of the two-way key. This two-way key is capable of connecting one cell in the circuit at once. If both the switches are switched on in the key, the unknown cells are in parallel connection.
3. A resistance box RBOX is shunted through a key K_2 . The common terminal of the two-way key (c) is connected to one end of RBOX.
4. The other end of the RBOX is connected to a galvanometer which is then joined to a jockey by its free end. The jockey can be slid on the potentiometer wire to obtain a null point in the galvanometer.
5. Plug is inserted in a and E_1 is connected to the circuit and plug c is inserted to complete the circuit.

6. The key K2 is left open, and rheostat resistance is minimal. High resistance (of the order of a thousand ohm) is removed from the resistance box. The jockey is touched at the zero ends of the potentiometer wire, and the direction of deflection in the galvanometer is considered.

7. Next, the jockey is brought in contact with the other end of the wire. The direction of deflection of the galvanometer needle must be opposite to that observed in the previous step; only then are the connections correct. Check connections if the deflections are in the same direction.

8. The jockey is gently slid over the potentiometer wire till the null point is obtained.

9. The key K2 is plugged in so that RBOX is short circuited and no resistance is offered. This makes a huge current flow, and the balance point can thus be found with more accuracy.

10. The length of the potentiometer wire is measured from point A to the point where the jockey is placed to find the null point. This length is noted as L1.

11. Now, a plug is inserted in b and E2 is connected to the circuit. The null point is obtained in a similar manner as was done for E1, and the length is noted as L2.

12. The rheostat is changed, and three different readings for L1 and L2 are obtained.

Observations

S.No	L1 cm			L2 cm			Ratio $E_1E_2=L_1L_2$	$\Delta(E_1E_2)$
	Cell E1			Cell E2				
	Jockey being moved in one direction	Jockey being moved in other direction	Mean	Jockey being moved in one direction	Jockey being moved in other direction	Mean		
1								
2								
3								
4								

Calculate $\frac{L_1}{L_2}$ for each set of readings since $E \propto L$ where E is EMF and L is length.

To Calculate Error:

$$\frac{\Delta \left(\frac{E_1}{E_2} \right)}{\frac{E_1}{E_2}} = \frac{\Delta L_1}{L_1} + \frac{\Delta L_2}{L_2}$$

$$\text{or, } \frac{\Delta E_1}{E_2} = \left(\frac{\Delta L_1}{L_1} + \frac{\Delta L_2}{L_2} \right) \frac{E_1}{E_2}$$

Result

The ratio of EMFs of the two unknown cells is:

$$\frac{E_1}{E_2} + \Delta \left(\frac{E_1}{E_2} \right)_{\text{max}}$$

$\frac{E_1}{E_2}$ is the main value of the ratio of EMFs of the two unknown cells.

Precautions

1. The resistance box must have good electrical contact for the keys plugged in.
2. To avoid creating any kinks in the potentiometer wire, the jockey should be slid with least pressure on it.
3. Prior to determining the balancing length with both cells, the position of the rheostat contact should not be altered for a single set of re

EXPERIMENT NO: 6

Measurement of Young's Modulus by Searle's Apparatus

Searle's Apparatus

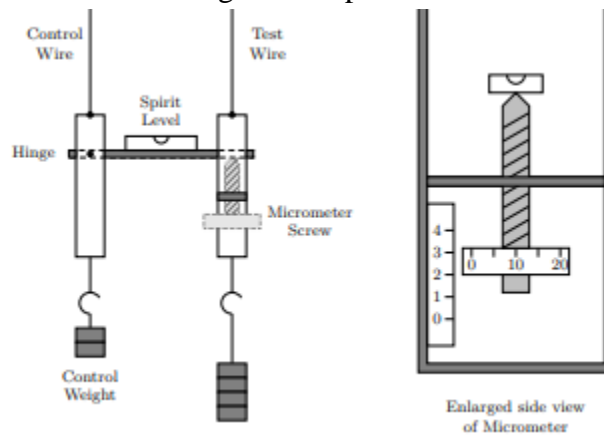
It consists of two wires (control or reference wire and test wire) of equal lengths and are attached to a rigid support (see figure). Both control and test wires are connected to a horizontal bar at the other ends. A spirit level is mounted on this horizontal bar. Now, this bar is hinged to the control wire. If we increase the weight on the side of test wire, it gets extended and causes the spirit level to tilt by a small amount. We can adjust any tilt of the spirit level by turning the screw of a micrometer, which is positioned on the test wire side. We restore it to the horizontal position to take the desired readings.

In a variation of Searle's apparatus, the control wire supports a vernier scale which will measure the extension of the test wire. The force on the test wire can be varied using the slotted masses. The micrometer is same as screw gauge. It has a main scale (shown vertically in the figure) and a circular scale (shown horizontally in the figure). When the screw is rotated to make the spirit level horizontal, the readings of the main scale and circular scale change. These readings are used to find the elongation l of the test wire.

Test Procedure

The test procedure is given below,

1. Measure the initial length L of the wire by using a meter scale.
2. Measure the diameter d of the wire by using a screw gauge. The diameter should be measured at several different points along the wire.
3. Adjust the spirit level so that it is in the horizontal position by turning the micrometer. Record the micrometer reading to use it as the reference reading.
4. Load the test wire with a further weight. The spirit level tilts due to elongation of the test wire.



5. Adjust the micrometer screw to restore the spirit level into the horizontal position. Subtract the

first micrometer reading from the second micrometer reading to obtain the extension l of the test wire.

6. Calculate stress and strain from the formulae.

7. Repeat above steps by increasing load on the test wire to obtain more values of stresses and strains.

8. Plot the above values on stress-strain graph; it should be a straight line. Determine the value of the slope Y .

Measurements

The wire may not be uniform or cross-section may not be exactly circular throughout the length of the wire. To avoid consequent error in the measurement of diameter, the screw-gauge reading is to be taken at different places and at mutually perpendicular directions at each place of the wire. Take mean value of these reading to get the average diameter.

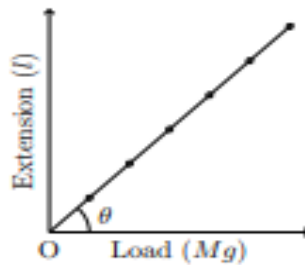
In one set of measurements, measure the elongation by increasing the test weight from the minimum value to the maximum value (loading) and in another set, measure the elongation by decreasing the test weight from the maximum value to the minimum value (unloading), in same number of steps. This helps in checking repeatability of the measurements. It also help in checking whether elastic limit is exceeded. Take the mean value of measurement during loading and unloading to avoid error due to hysteresis effect. The measurements may be recorded in the following format

Weight	Micrometer Reading			Elongation (l)
	Loading	Unloading	Mean	

Results

Plot the calculated values of stress and strain on the stress-strain curve. Estimate the slope of this curve in the linear region to get the Young's modulus of the material of the wire.

You can also use the measured data to plot the load ($F = Mg$) versus extension l curve. This curve should be a straight line passing through the origin (see figure). The slope of this



$$Y = \frac{4L F}{\pi d^2 l} = \frac{4L}{\pi d^2 \tan \theta}$$

line gives $\tan \theta = l/F = l/(Mg)$. Substitute l/F in the expression of Young's modulus to get
 Substitute the measured value of L , measured value of d and estimated value of $\tan \theta$ (from graph) to get Young's modulus.

Points to ponder

1. Will there be any error if the control (or reference) wire and the test wire are not of the same material? If wires are of different material then their thermal expansion (due to temperature change during experiment) will be different. This will introduce an error in the measured elongation l .
2. The wires used in the experiment are identical, long and thin. The long and thin wires gives larger elongation and hence better measurement accuracy.
3. The wires should be taut otherwise length L can not be measured correctly. The control weight or dead weight is used to make the wires taut.
4. List out various sources of errors and ways to reduce them.
5. When a set of readings are taken, the micrometer screw must be rotated in the same direction to avoid back-lash error. The micrometers (screw gauges) usually have back-lash error. It is the maximum change in micrometer reading to start physical movement of the screw in reverse direction. You can experience this error with a simple nut and bolt.
6. After adding a load or removing a load, wait for some time before taking the next reading; this will help the wire to elongate or contract fully.

Experiment No: 7

P-N JUNCTION DIODE CHARACTERISTICS

AIM:

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

Components:

Name	Qty
Diodes IN 4007(Si)	1
Resistor 1K Ω , 10K Ω	1

Equipment:

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

Theory:

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

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

the diode, due to electrons crossing the junction and entering P-side of the diode). Assuming current flowing through the diode to be very large, the diode can be approximated as short-circuited switch.

If -ve terminal of the input supply is connected to anode (p-side) and +ve terminal of the input supply is connected to cathode (n-side) then the diode is said to be reverse biased. In Name Qty Diodes IN 4007(Si) Resistor 1K Ω , 10K Ω 1 1 this condition an amount equal to reverse biasing voltage increases the height of the potential barrier at the junction. Both the holes on p-side and electrons on n-side tend to move away from the junction thereby increasing the depleted region. However the process cannot continue indefinitely, thus a small current called reverse saturation current continues to flow in the diode. This small current is due to thermally generated carriers. Assuming current flowing through the diode to be negligible, the diode can be approximated as an open circuited switch.

The volt-ampere characteristics of a diode explained by following equation:

$$I = I_0 (e^{v/(\eta v_T)} - 1)$$

where I=current flowing in the diode

I_0 =reverse saturation current

V=voltage applied to the diode

V_T =volt-equivalent of temperature = $kT/q = T/11,600 = 26\text{mV}$ (@ room temp).

$\eta=1$ (for Ge) and 2 (for Si)

It is observed that Ge diode has smaller cut-in-voltage when compared to Si diode. The reverse saturation current in Ge diode is larger in magnitude when compared to silicon diode.

Procedure:

Forward Biased Condition:

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

Circuit Diagram

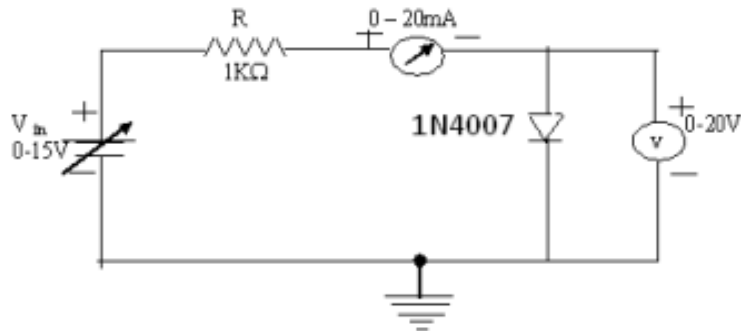
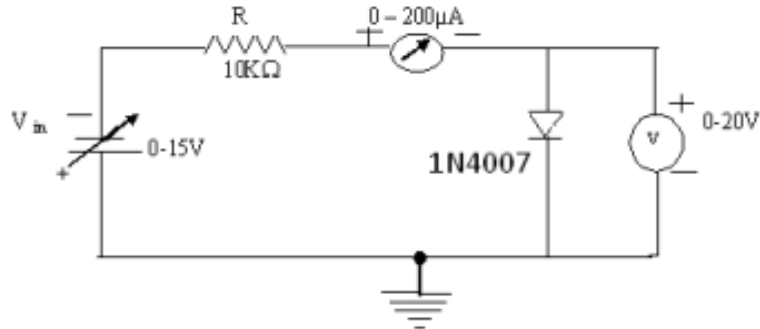


Fig (2) - Reverse Biased condition:



Reverse biased condition:

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

Observations

Si diode in forward biased conditions:

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

Si diode in reverse biased conditions:

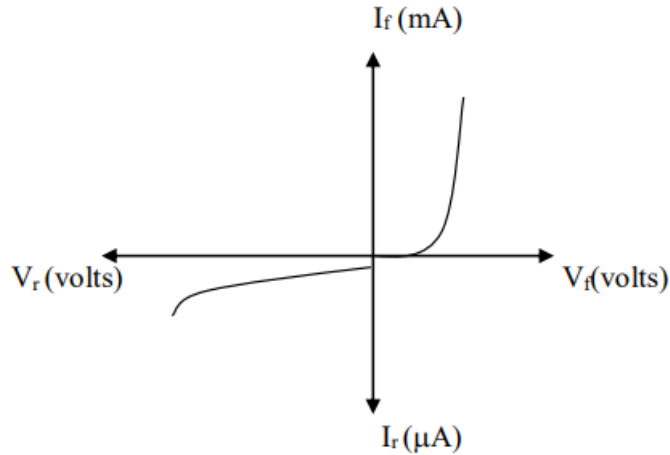
Sl. No	RPS Voltage	Reverse Voltage across the diode V_r (volts)	Reverse current through the diode I_r (μA)

Graph (Instructions):

1. Take a graph sheet and divide it into 4 equal parts. Mark origin at the center of the graph sheet.
2. Now mark
 - + ve x-axis as V_f
 - Ve x-axis as V_r
 - + Ve y-axis as I_f
 - ve y-axis as I_r .

3. Mark the readings tabulated for Si forward biased condition in first Quadrant and Si reverse biased condition in third Quadrant.

Calculations from Graph:



Static forward Resistance $R_{dc} = V_f / I_f \Omega$

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

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

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

Precautions:

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

Result:

1. Cut in voltage = V
2. Static forward resistance = Ω
3. Dynamic forward resistance = Ω

EXPERIMENT NO : 8

Newton's Rings

OBJECTIVE: To find the wavelength of Sodium light by Newton's ring.

APPARATUS USED:

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

FORMULA USED:

The wavelength of light is given by the formula

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

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

D_n = diameter of n th ring,

p = an integer number,

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

PROCEDURE:

If a point source is used only then we require a convex lens otherwise while using an extended source, convex lens L1 is not required. Before starting the experiment the glass plates G1 and G2 and the plano-convex lens L2 should be thoroughly cleaned. The centre of lens L2 is well illuminated by adjusting the inclination of glass plate G1 at 45° as shown in figure 1 (Left).

•Focus the eyepiece on the cross-wire and move the microscope in the vertical plane by means of rack and pin on arrangements till the rings are quite distinct. Adjustments are to be done till satisfactory fringe system of perfect circular shape with a dark spot at the centre is obtained. The microscope is focused to get clear dark and bright fringes in the field of view as shown in figure 1 (right). Clamp the microscope in the vertical side.

•First, the microscope is adjusted so that the Centre of the cross wires coincides with the central dark spot of the fringe system. The microscope is then moved slowly either towards left or right of the centre. While the microscope is moved, the number of dark rings is counted say, up to 14. At the 14th dark ring the microscope is stopped and its motion is reversed. It is brought back to the position of 12th ring. The vertical cross wire is adjusted such that it will be tangential to the 12th dark ring. In this position the reading of the microscope is noted. The microscope is then moved to the 10th dark ring such that the vertical cross wire is again tangential to the ring. The reading of

the microscope is noted. The above process is continued till 2th dark ring is reached. After taking the reading for the 2th ring the microscope is moved in the same direction on to the opposite side of the centre. The microscope is moved till the 2th dark ring on the opposite side is reached. The reading is taken as before for the 2th dark ring. The measurements are continued on the opposite side till 12th dark ring is reached. The observations are noted in table. The radius of the curvature can be determined by the using a spherometer. In this case,

$$R = \left(\frac{l^2}{h} \right) + \left(\frac{h}{2} \right)$$

Where l is the distance between the two legs of the spherometer as shown in figure 2 (right) and h is the difference of the readings of the spectrometer when it is placed on the lens as well as when placed on the plane surface.

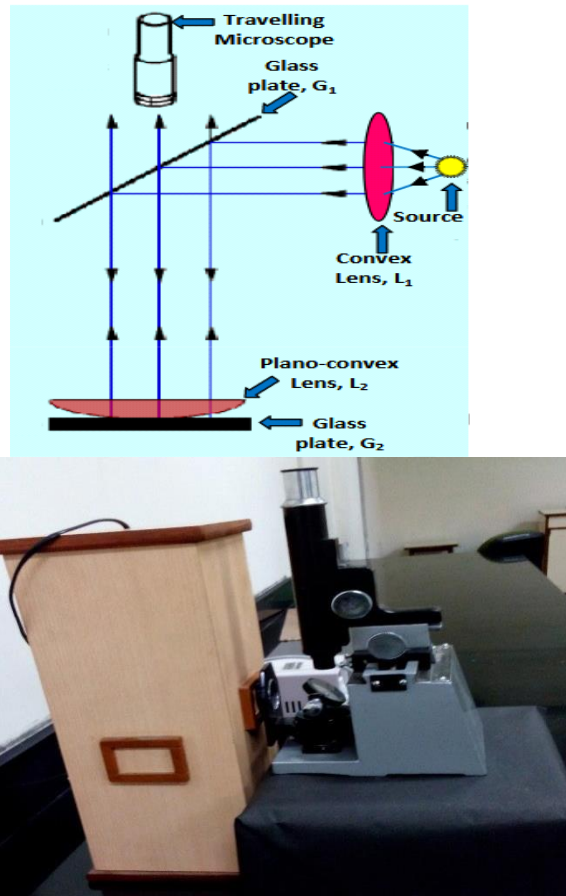


Figure: Left: Experimental arrangement to obtain Newton's ring. Right: Newton's ring apparatus.



OBSERVATION:

Value of one division of the main scale=..... cm.

No of division on the vernier scale=.....

Least count of the travelling microscope =..... cm.

(A) Table for determination of $(D_{n+p}^2 - D_n^2)$:

Sr. No.	No. of the ring	LHS reading in cm			RHS reading in cm			Diameter $D=(L\sim R)$	D^2 in cm^2	$D_{n+p}^2 - D_n^2$ in cm^2
		MSR	VSR	TR(L)	MSR	VSR	TR(R)			
1	12							$a =$	$a - d =$	
2	10							$b =$		
3	8							$c =$	$b - e =$	
4	6							$d =$		
5	4							$e =$	$c - f =$	
6	2							$f =$		
For $p = 6$, Mean $D_{n+p}^2 - D_n^2$										

(B) Table for determination of R using spherometer:

Distance between the two legs of spherometer $l =$ cm.

Sr. No.	Spherometer reading on plane surface			Spherometer reading on lens surface			$h = (b-a)$ in cm
	MSR	VSR	TR(a)	MSR	VSR	TR(b)	
1							
2							
3							
Mean, h in cm							

MSR = Main Scale Reading VSR= Vernier Scale Reading TR- MSR+ VSR= Total Reading

CALCULATIONS:

Using h and l obtained in Table (B), the radius of curvature of the plano-convex lens R is given by:

$$R = \left(\frac{l^2}{h}\right) + \left(\frac{h}{2}\right)$$

Using $D_{n+p}^2 - D_n^2$ obtained in table [A] for $p=6$, the wavelength of sodium light is given by

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

$$\lambda = (D_{n+p}^2 - D_n^2) / 4pR = \text{..... angstrom}$$

RESULT:

The mean wavelength λ of sodium light = \AA

Standard mean wavelength $\lambda = \text{..... } \text{\AA}$

Percentage Error =%

SOURCES OF ERROR and PRECAUTION:

- (1) Glass plates and lens should be cleaned thoroughly.
- (2) The plano-convex lens should be of large radius of curvature.
- (3) The sources of light used should be an extended one.
- (4) The range of the microscope should be properly adjusted before measuring the diameters.
- (5) Crosswire should be focused on a dark ring tangentially.
- (6) The centre of the ring system should be a dark spot.
- (7) The microscope is always moved in the same direction to avoid back lash error.
- (8) Radius of curvature should be measured accurately.

EXPERIMENT NO: 9

Diffraction Grating

OBJECTIVE: To determine the wavelength of mercury light by using a plane Diffraction Grating and Spectrometer.

APPARATUS: Spectrometer, grating and holder, mercury arc lamp, sodium lamp (optional), various discharge tubes and accessories

Introduction

A spectrometer is an instrument used for studying electromagnetic emissions. In this experiment a spectrometer equipped with a diffraction grating is used to identify specific wavelengths from the emission spectrum of mercury, to measure these wavelengths precisely, and to compare them to accepted values.

Procedure

Adjust the diffraction grating so that the normal to its plane makes a small angle α to the incident beam of light. This is shown schematically in Fig. 1. Since $\alpha=0$ (Almost), the angles between the first and zeroth order intensity maxima on either side, θ and θ' respectively, are related to the wavelength λ of the incident light according to [1]

$$\lambda = d \sin(\varphi), \dots\dots\dots (1)$$

accurate to first order in α . Here, d is the separation between the slits of the grating, and

$$\varphi = (\theta' + \theta)/2 \dots\dots\dots (2)$$

Four visible spectral lines of mercury are depicted in Fig. 2. The accepted values of their wavelengths and color associations are summarized in Table 1. To determine the wavelengths of these spectral lines proceed as follows:

1. Turn on the power supply to which is attached the mercury discharge tube.

Color	Wavelength [nm]
Violet	435.8
green	546.1
yellow-1	577.0
yellow-2	579.1

Table 1: A summary of wavelengths and color associations of the visible Spectral lines of mercury, as depicted in Fig. 2.

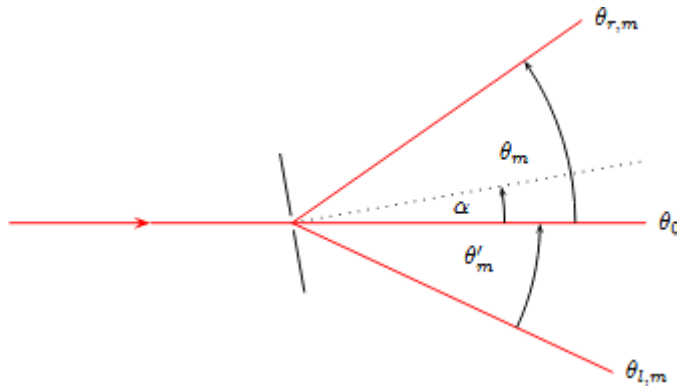


Figure 1: A depiction of the m -th maximum for monochromatic light being dispersed by a diffraction grating. The angle α is the angle the normal to the diffraction grating makes with respect to the incident beam of light. The quantity θ_0 is the angular coordinate of the zeroth order maximum. The quantities $\theta_{l,m}$ and $\theta_{r,m}$ are the angular coordinates of the m -th order maxima to the left and right of the zeroth order maximum.

2. Align the telescope so that the cross hairs in the eyepiece are centered on the light emerging from the collimator tube. Adjust the platform on which the diffraction grating is placed so that the 0 degree marking on the vernier aligns with an angular marking on the scale between the 35^{degree} and 325^{degree} .

3. Attach the diffraction grating to the platform on the spectrometer.

4. Attach the diffraction grating to the platform on the spectrometer. The normal to the plane of the grating should be aligned with the direction of the beam, i.e. α should be close to zero. If the diffraction grating is positioned properly, the angles θ_m and θ'_m are approximately equal, i.e. they should not differ by more than a degree.

5. Identify the first order maxima of the four visible spectral lines to the left of the collimating tube.

6. Measure the angles of the violet, green, and yellow-2 lines. Report them as θ_l in Table 2. Note: because of the vernier scale angles can be measured to an accuracy of 1^{degree} .

7. Perform the corresponding measurements for the first order maxima to the right of the collimating tube and report their values as θ_r .

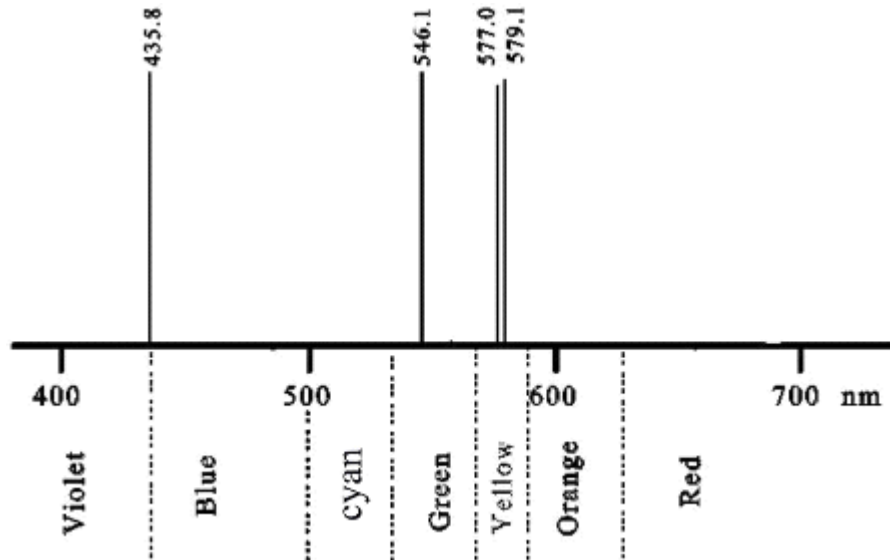


Figure 2: The visible lines of the mercury spectrum are depicted. These lines are denoted, from left to right, violet, green, yellow-1, and yellow-2.

8. Calculate ϕ for each spectral line. According to Fig. 1 one can re-express Eq. 2 as

$$\phi = \frac{|\theta_l - \theta_r|}{2} . \quad \dots\dots\dots (3)$$

Report their values in Table 2.

9. Using Eq. 1 with $d = 1.6667 \times 10^3 \text{ nm}$, calculate the experimental value of each wavelength and report them in Table 2.

10. Calculate the fractional deviation of each wavelength and report the values in Table 2. The fractional deviation F is defined as

$$F = \frac{|\lambda_{\text{exp}} - \lambda_{\text{accepted}}|}{\lambda_{\text{accepted}}} . \quad \dots\dots\dots (4)$$

	$\theta_{i,1}$ [deg]	$\theta_{r,1}$ [deg]	ϕ_1 [deg]	λ_{exp} [nm]	$\lambda_{accepted}$ [nm]	F
Violet						
Green						
Yellow-2						

Table 2: Data and Calculations

DATA SHEET

Central Image

Vernier A	Vernier B
_____	_____
_____	_____
_____	_____
_____	Mean _____

1st Order - Hg Green, Right Side

Vernier A	Vernier B
_____	_____
_____	_____
_____	_____
_____	Mean _____

1st Order - Hg Green, Left Side

Vernier A	Vernier B
_____	_____
_____	_____
_____	_____
_____	Mean _____

2nd Order - Hg Green, Right Side

Vernier A	Vernier B
_____	_____
_____	_____
_____	_____
_____	Mean _____

Wavelengths of Spectral Lines

Mercury

$\lambda(\text{\AA})$	Color	Intensity
4047	Violet	Very Bright
4078	Violet	Weak
4358	Blue-Violet	Bright
4916	Blue-Green	Weak
5461	Green	Very-Bright
5770	Yellow	Bright
5791	Yellow	Bright

EXPERIMENT NO: 10

Helmholtz Galvanometer

AIM - To study the variation of magnetic field with distance along the axis of Helmholtz galvanometer and to estimate the radius of the coil.

APPARATUS - Helmholtz galvanometer, magnetometer compass box, ammeter (measure mA), battery eliminator, rheostat, commutator, plug key, connecting wires.

THEORY- The term Helmholtz coils refers to a device for producing a region of nearly uniform magnetic field. It is named in honor of German physicist Hermann von Helmholtz. It consists of two identical circular magnetic coils that are placed symmetrically parallel to each other and on a common axis, z- axis. The rings have radius r and they are separated by a distance equal to or slightly larger than r . Each coil carries an equal electrical current flowing in same direction.



Helmholtz coils

The first step to calculate the field of a pair of Helmholtz coil is to calculate magnetic field intensity F produced by each ring.

If a current (I) is allowed to flow through a wire of length (l), and the wire is bent into an arc of radius r , then the magnetic field intensity (F) at center of the arc is

$$F = \frac{\mu_0 I l}{4 \pi r^2}$$

Where μ_0 = Permeability of free space (8.854×10^{-12} F/m)

For a circular coil of n turns we substitute $l = 2\pi r n$ in equation (1)

$$F = \frac{\mu_0 I n}{2r}$$

Now, substituting the value of μ_0 in equation (2)

The magnetic field produced by each ring is given by

$$F = \frac{2\pi n l}{r \times 10^7}$$

The magnetic field at any point on axis at a distance (x) from centre of coil is

$$F = \frac{2\pi n I r^2}{10^7 (x^2 + r^2)^{\frac{3}{2}}}$$

The rate of variation of magnetic field

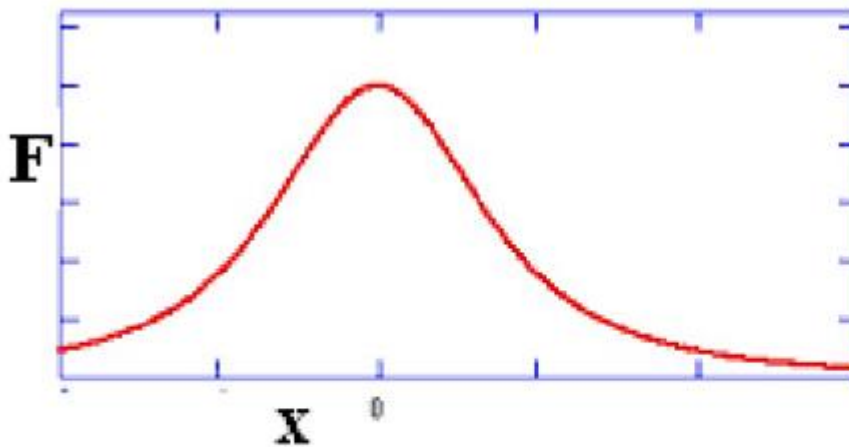


Figure2. Magnetic field generated by a coil with radius (r) =1m.

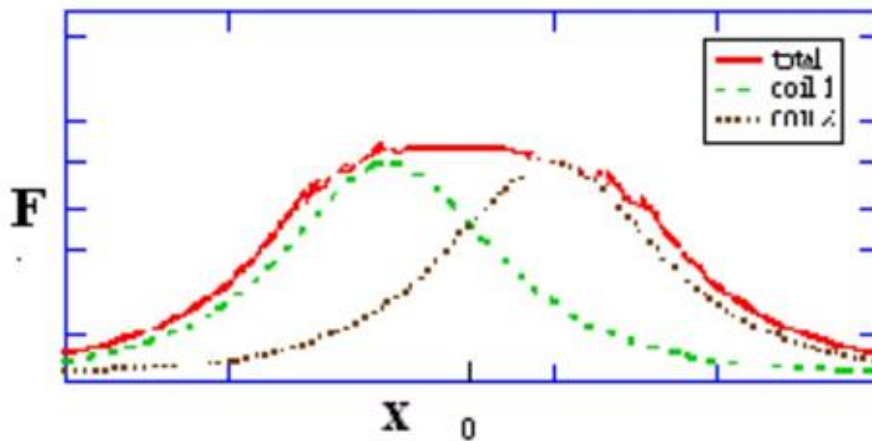


Figure3. Magnetic field generated by a pair of Helmholtz coils

Therefore,

$$\frac{dF}{dx} = -3x[(2\pi n i r^2)(x^2 + r^2)^{-\frac{5}{2}}]$$

$$\frac{d^2F}{dx^2} = [-6\pi n i r^2(x^2 + r^2)^{-\frac{5}{2}} - 5x^2(x^2 + r^2)^{-\frac{7}{2}}]$$

From which, $x = \pm r/2$, if $\frac{d^2F}{dx^2} = 0$ or $\frac{dF}{dx} = \text{constant}$.

Thus at point $x = \pm r/2$ from centre of coil, $\frac{dF}{dx} = \text{constant}$

We observe that in figure3, the rate of increase of field due to one coil at midpoint between the coils is equal to the rate of decrease of field due to the other at the same point. Therefore if one moves away along the axis from the midpoint, any diminution in the intensity of the field due to one coil is

The coil is placed in the magnetic meridian, the magnetic field due to the current I flowing in the coil is perpendicular to H (Horizontal component of earth's magnetic field). Thus the magnetic needle is acted upon by two uniform magnetic fields F and H at right angles to each other.

The magnetic needle will make an angle with H in the equilibrium position.

MAGNETOMETER: The magnetic compass box used in this experiment is called Magnetometer. The red point in the magnetometer corresponds to North direction (Red is analogous to positive terminal of electrical circuit.). Thus in absence of magnetic field the needles are in east west direction and while performing the experiment in order to avoid to the Earth's horizontal magnetic field the bench of the Helmholtz galvanometer should be kept in east-west direction.

PROCEDURE-

1. The Helmholtz coils should be parallel to themselves and perpendicular to the bench and at a distance equal to $\frac{r}{2}$ on either side from centre of the bench.
2. Magnet compass box is kept at the centre of the sliding bench, such that magnetic needle is at the centre of the coils.
3. The bench of the Helmholtz galvanometer should be kept in east-west direction
4. Base of the coil is levelled with the help of spirit level and levelling screws.
5. Connections are made as shown in figure using say 50 turns of the coil and taking care that out of the four terminals provided on the commutator K any two diagonally opposite terminals are joined to the galvanometer and the other two to the battery through rheostat.

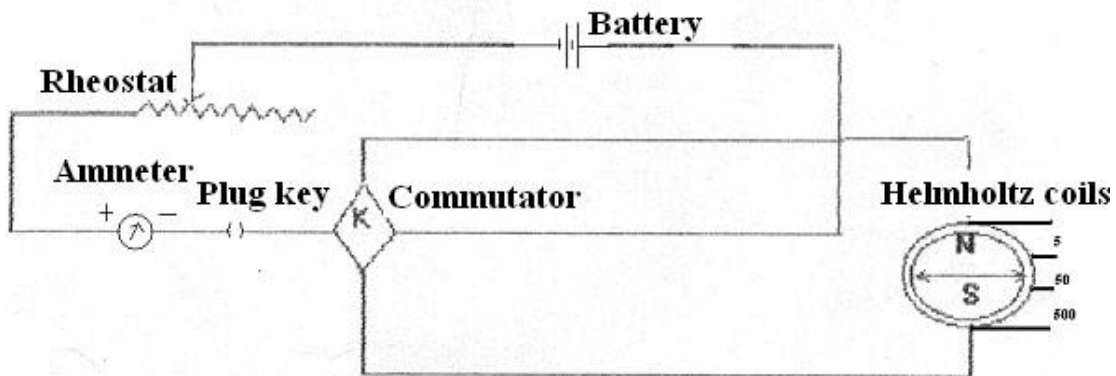


Figure. Circuit diagram

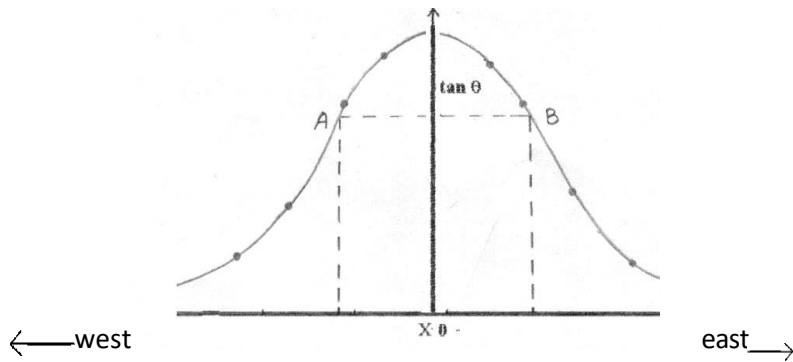
6. Adjust the current in the coil with the help of rheostat such that the deflection in the magnetic needle is of the order of 45° at centre of bench for both direct and reverse current.
7. Now move the compass box through 2 cm and note the deflection in east and west direction of magnetometer for direct and reverse current respectively.
8. Continue to take readings till $\pm 15^\circ$ deflection is obtained in the compass box with respect to 45° .
9. Repeat the procedure for other side.
10. Calculate mean θ and find $\tan \theta$ according to the observation table.
11. Plot a graph taking x on x-axis and $\tan \theta$ on y-axis respectively for each side. Mark the points of inflection on the curve. The distance between the two points will be the diameter of the coil.
12. The circumference of the coil can be measured by a thread and its radius can be calculated to verify the value obtained from the graph

OBSERVATIONS-

S.No.	Position of the needle on one of the scale. (Distance of Compass box from center of coil) x (cm)	Deflection in the needle when it is on one side of bench					
		Current one way		Current reversed		Mean θ (degree)	Tan θ
		θ_1 East end of needle	θ_2 West end of needle	θ_3 East end of needle	θ_4 West end of needle		
1.	0						
2.	2						
3.	4						
4.	6						
5.	8						
6.	10						
7.	12						
8.	14						
9.	16						
10.	18						
11.	20						
12.	22						
13.	24						
14.	26						
15.	28						
16.	30						

S.No.	Position of the needle on one of the scale. (Distance of Compass box from center of coil) x (cm.)	Deflection in the needle when it is on other side of bench					
		Current one way		Current reversed		Mean θ degree	Tan θ
		θ_1 East end of needle	θ_2 West end of needle	θ_3 East end of needle	θ_4 West end of needle		
1.	0						
2.	2						
3.	4						
4.	6						
5.	8						
6.	10						
7.	12						
8.	14						
9.	16						
10.	18						
11.	20						
12.	22						
13.	24						
14.	26						
15.	28						
16.	30						

GRAPH:



CALCULATION-

Circumference of the coil as obtained by a thread and meter scale =cm.

Radius of the coil, as obtained from the graph = distance between the points A and B.

Radius of the coil, as obtained from measurement = $\frac{\text{Its Circumference}}{2\pi}$ (6)

MAXIMUM PROBABLE ERROR:- This is obtained by taking logarithmic differentiation of equation (6)

RESULT: - 1. The variation in the magnetic field with distance, along the axis of the given coil is as shown in the graph.

2. Radius of the coil = _____ cm. as obtained from the graph
and _____ cm. as obtained from
measurement.

PRECAUTIONS-

1. Connections should be clean and tight.
2. Circuit should be properly connected and checked before turning it "ON". No. of turns should be equal in both coils.
3. Plug key should be used in circuit and it should not be closed while making connections or taking reading.
4. The coil should be adjusted properly in the magnetic meridian.
5. The apparatus should be at considerable distance from current carrying conductors and magnetic materials.
6. The positive marked terminal of the ammeter should be always connected to positive terminal of battery.
7. While taking readings there can be error due to parallax which should be avoided.
8. Readings at both ends of the pointer should be taken.

SOURCES OF ERROR-

1. Connections might not be tight.
2. Magnetic needle might not be pivoted at center.
3. Galvanometer coil might not be exactly in magnetic meridian.