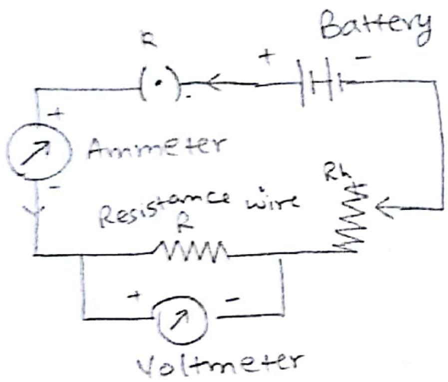
Index

Sl No.	Name of the Experiment	Page No.	Date of Experiment	Date of Submission	Remarks
1.	To Determine Resistance per cm of a Given Wire	1	19/4		
2.	To Determine Resistance of Given Wire using Metre Bridge	5	3/5		
3.	To Verify laws of Series Combination using metre bridge	13	9/5		
4.	To verify laws of Parallel Combination using metre bridge	13	5/7		
5.	To Compare the EMF using Potentiometer	18	19/7		
6.	To Determine Internal Resistance of Given Cell using Potentiometer	21	3/8		
7.	To Determine Internal Resistance of Galvan--ometer by Half Deflection Method	23	10/8		
8	To Find Figure of Merit of a Galvanometer	25	17/8		
9.	To convert Galvanometer into an ammeter.	27	28/8		
10.	To convert Galvanometer into a Voltmeter	30			

Index

Scanned by CamScanner

Aim :- To determine the resistance per cm of a given wire by plotting a graph of potential difference versus current



circuit to find the resistance of a wire

Aim :- To determine the resistance per cm of a given wire by plotting a graph of potential difference versus current.

Apparatus :-
About 100 cm long resistance wire of about 10 ohm resistance in the form of coil, a battery eliminator or an accumulator or two dry cells (0 to 3V), d.c. voltmeter (range 3V), d.c. ammeter (range about 500 mA), a rheostat, one plug key, thick connecting wires, sand paper etc.

Theory
According to Ohm's law, "The current flowing through a conductor is directly proportional to the potential difference across its ends provided the physical conditions of the conductor (temperature, dimensions etc) remain the same.

Let 'I' be the current flowing through the conductor and 'V' be the potential drop across its ends,

then $I \propto V$

or $V \propto I$

or $V/I = \text{constant} = R$

or $R = V/I$ ...... working Formula

where R is a constant depending upon the dimensions (length and radius and material of the wire. R is called electrical resistance and it is expressed in ohm whereas V is measured in volt and the

Teacher's Signature : ____________

Observation Table

Variation of Potential Drop with Current

S.No.	Ammeter reading I (Ampere)		Voltmeter reading V (Volt)		Ratio V/I = R (ohm)
	observed I_o	Corrected $I = I_o + (-e_1)$	observed V_o	Corrected $V = V_o + (-e_1)$	
1	50	50	65	65	1·3
2	60	60	85	85	1·4
3	70	70	95	95	1·35
4	80	80	105	105	1·31
5	90	90	120	120	1·33

mean value of resistance, R = 1·33 ohm

Observation -

Ranges of instruments : Ammeter - 0-250 mA
Voltmeter - 0-500 mV

Least Counts of : Ammeter scale - 5 mA
Voltmeter scale - 20 mA

length of the resistance wire (l) - 38 cm

Date

Expt. No.   Page No. 2

current I in ampere.

A study of current-voltage relationship would require an arrangement in which potential drop V can be varied across the resistance wire and the corresponding current I can be measured.

With the variation of potential drop V, the variation of current I is noted. The actual I-V variation would be best depicted if a graph is plotted by taking the values of V along the abscissa (x-axis), and the corresponding values of I along the ordinate (y-axis).

Since Ohm's law requires that for a given conductor, the drop of potential 'V' across its ends is directly proportional to the current I, the (V-I) graph is expected to be a straight line. The Slope (V/I) of this line is a measure of the resistance of the conductor.

Observations and Calculations.

1. Ranges of instruments : Ammeter = 0-250 mA
   Voltmeter = 0-500 mV
2. least counts of :
   Ammeter scale = 5 mA
   Voltmeter scale = 20 mV
3. zero errors and zero corrections
   Zero error of the ammeter, e_1 = 0 A
   zero correction of the ammeter, $(-e_1)$ = 0 A
   zero error of the voltmeter e_2 = 0 V

Teacher's Signature :

zero correction of the voltmeter $(-e_2)$ = 0 V

4. length of the resistance wire l = 38 cm

Graph -

Choose appropriate scales and plot a graph between the values of V corresponding to various values of I, taking I along the x-axis and V along the y-axis as shown.

Draw a straight line best fitting through all the points on the graph. Select two points A and B on the graph. Draw the line AC perpendicular to the x-axis and the line BC perpendicular to the y-axis through B.

Calculations :-

1. Calculate the value of slope of V-I graph.

$$\text{Slope} = \frac{\Delta V}{\Delta I} = \frac{AC}{BC} = \frac{\text{Reading (in Volt) at A} - \text{Reading at C}}{\text{Reading (in Amp) at C} - \text{Reading at B}}$$

2. Resistance per unit length = $\frac{R}{l}$ = 0.035 ohm cm^{-1}
= 3.5 ohm m^{-1}

Precautions

1. First of all, the circuit should be drawn and got checked.
2. The connecting wires used should be thick copper wire and the insulation of their ends should be removed by rubbing them with a sand paper.

Date

Expt. No.

3. Connections ~~xxx~~ should be tight.

Result

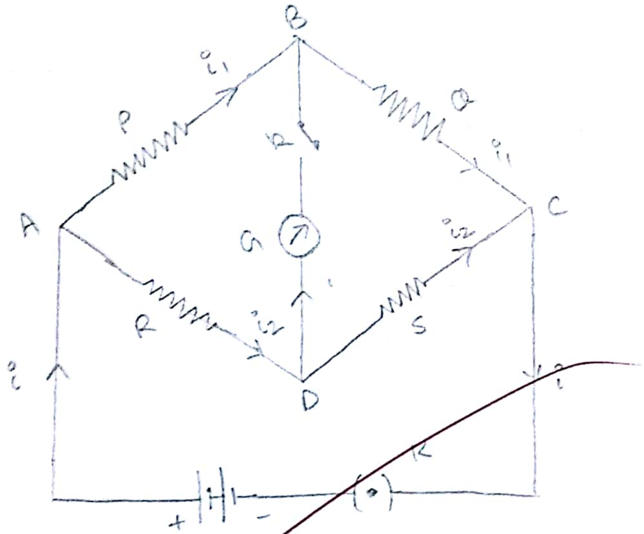
i) Graph between Potential drop 'V' and the current through the conductor 'I' is a straight line.

ii) The resistance of the given wire is 1.33 ohm.

iii) The resistance per cm of the given wire is 0.035 ohm per cm.

Teacher's Signature :

Aim :- To find the resistance of a given wire using a metre bridge and hence determine the specific resistance of its material.



Wheatstone's Bridge Network

Date ....

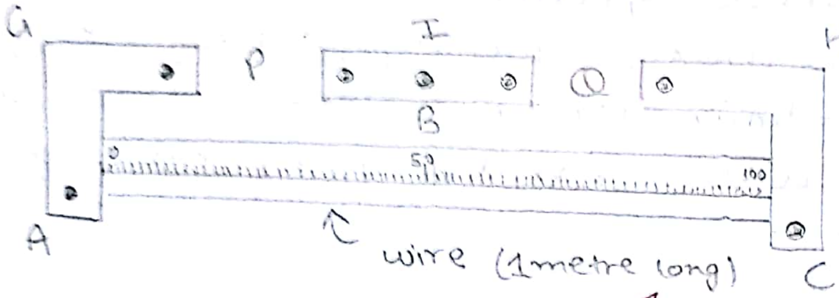
Expt. No. A-2   Page No. 5

Aim :- To find the resistance of a given wire using a meter bridge and hence determine the specific resistance of its material.

Apparatus :-
A meter bridge, a wire about 1 metre long (of the material whose specific resistance is to be determined) a resistance box, a jockey, a key, a galvanometer a battery eliminator or a lechlanche cell, thick connecting wires, sand paper, screw gauge, S.W.G. tables etc.

Theory -
An accurate method to determine the value of a resistor is by using wheatstone's Bridge arrangement. The bridge consists of four resistor P, Q, R and S joined such that they form a quadrilateral ABCD as shown in fig. The terminals A and C are joined to two terminals of a cell. The other pair of junctions B and D are connected to a galvanometer G through a key K.
The current i drawn from the cell is divided at A into two parts. One part i_1 flows along the path ABC and the other part i_2 flows along ADC. Since the potential falls uniformly along the two conductors, it is possible to find two points B and D, such that they are at the same

Teacher's Signature : ____________



Metre Bridge

potential. If B and D are connected with a key K through a Galvanometer G, no current will flow throw G on closing key K. Hence there will be no deflection in the galvanometer and the bridge is said to be balanced. Let i_1 and i_2 be the currents in arms ABC and ADC respectively and let V_a, V_b, V_c and V_d be the potentials at the points A, B, C and D respectively in the balanced condition, then

$$V_a - V_b = V_a - V_d$$

and $$V_b - V_c = V_d - V_c$$

Applying ohm's law, we get

$$V_a - V_b = P i_1$$
$$V_b - V_c = Q i_1$$
$$V_a - V_d = R i_2$$
$$V_d - V_c = S i_2$$

Therefore, for the balanced bridge

$$P i_1 = R i_2$$
$$Q i_1 = S i_2$$

or $$\frac{P}{Q} = \frac{R}{S}$$

If three resistances Q, R and S are known the value of the fourth resistance P can be calculated

$$P = \frac{R}{S} \times Q$$

Metre Bridge ie Slide Wire Bridge

It is a smple apparatus based on the principle of Wheat stone's bridge. It consists of a metre long

Teacher's Signature :

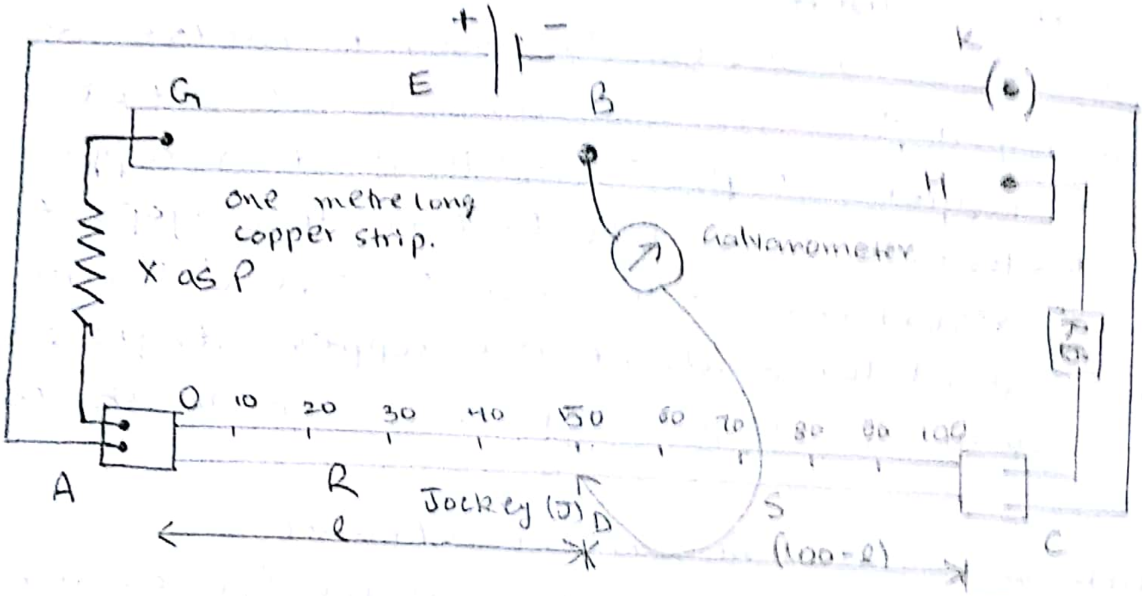
wire AC of uniform area of cross-section and stretched on a wooden board. A metre scale is fixed along it. The ends A and C are attached to two thick copper strips G and H. Another copper strip I is fixed between G and H to form two gaps for introducing resistance at P and Q. Screw terminals are attached at the ends of the copper strips and also in the middle of strip I at B for making connections.

Measuring ~~an~~ Unknown Resistance

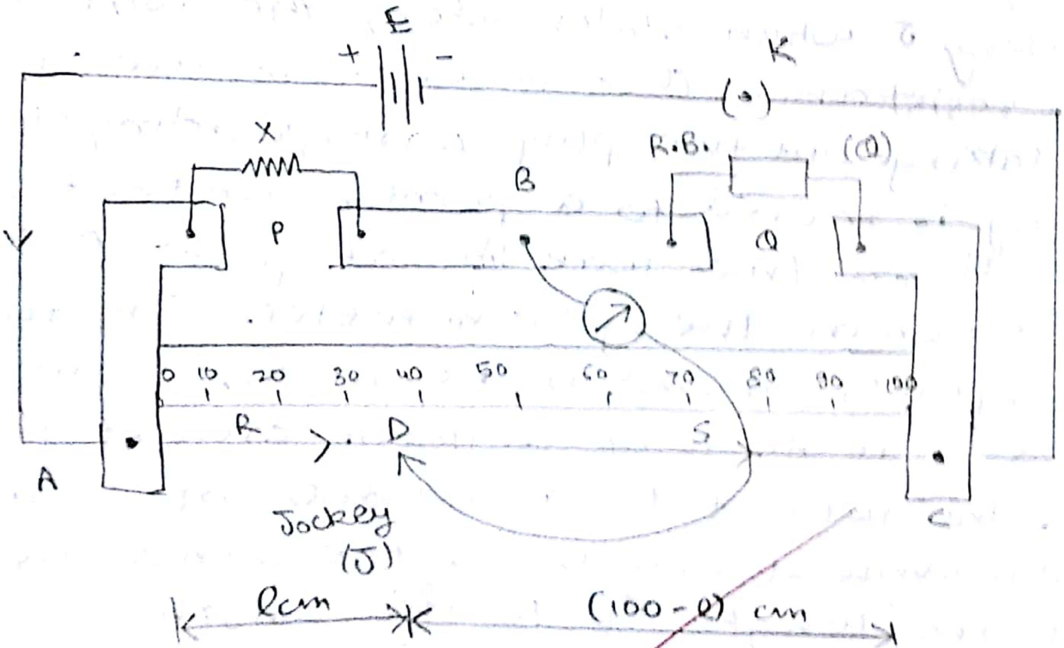
Resistance X of unknown value under observation is inserted in the gap P and a resistance box RB is placed in gap Q. The terminal B is joined to one end of the galvanometer G whose other end is joined to a jockey J which slides along the wire AC. A known resistance Q is inserted in the resistance box by taking out the plug corresponding to it and the jockey is moved to a point, such that on pressing it on the wire AC at point D there is no deflection in the galvanometer. In this position, points B and D are at the same potential. Since the wire AC is of uniform area of cross section, the ratio of the resistance of arm AD to the resistance of arm DC is the same as the ratio of the length AD to the length DC.

$$\text{Therefore, } \frac{X}{Q} = \frac{R}{S} = \frac{\text{Resistance of length AD}}{\text{Resistance of length DC}}$$

$$= \frac{k \times \text{length AD}}{k \times \text{length DC}}$$



Another form of metre bridge



a) Measuring the unknown resistance of a wire by metre bridge.

for a wire of uniform cross-section $a, R \propto l$ or $R = kl$. Here k is the resistance of wire per unit length.

If length AD = l cm, then length DC = $(100 - l)$ cm

$$X = Q \times \frac{AD}{DC} = \frac{Q \times l}{100 - l}$$

Since l can be measured and Q is known, X can be determined

Another form of Metre Bridge

Another form of metre bridge used these days is shown in Fig. It differs from the conventional bridge in the manner that a metre long strip is fixed parallel to the one metre long constant wire at a distance of about 10 cm from it. Two terminals G and H are provided at the ends and another terminal B in the middle of the strip.

The connections are made as shown in Fig 3.8. The unknown resistance X is connected as P in between the terminals A and G and resistance box (R.B.) as Q between H and C one terminal of the galvanometer is connected to the terminal B on the strip and the other is connected to a jockey J which can be made to slide on the wire AC of the metre bridge. X and Q form one set of arms of the wheatstone's Bridge and AJ and JC from the other set of arms as R and S, adjusted such that it balances the bridge, then

$$\frac{X}{Q} = \frac{\text{Resistance of length AJ}}{\text{Resistance of length JC}} = \frac{k.l}{k(100 - l)}$$

Teacher's Signature : ....

Observation for resistance of wire

No. of Obs.	Resistance Q (ohm)	Balancing length AD = l (cm)	Length DC = 100 - l (cm)	$X = \frac{l}{100-l} \times Q$ = X_1 (ohm)
1	0.5	62.2	37.8	0.82
2	0.7	54.0	46	0.82
3	1.0	45.2	54.8	0.81
4	1.5	35.5	64.5	0.82

mean value of resistance, $X = \frac{X_1 + X_2 + X_3 + X_4}{5} = 0.82$ ohm

Date

Expt. No.

$$\frac{X}{Q} = \frac{l}{100-l}$$

where R the resistance per unit length cancels for a wire of uniform cross section and homogeneous composition.

$$X = \frac{l}{100-l} \times Q$$ .... working formula

Specific Resistance

The resistance of a resistor varies directly as its length L and inversely as its area of cross-section πr^2, where r is the radius of the wire.

$\therefore X \propto L$

and $X \propto (L/A)$ where $A = \pi r^2 = \frac{\pi d^2}{4}$.

r being the radius and d is the diameter of the wire.

Therefore $X = \rho \frac{4L}{\pi d^2}$, where ρ is specific resistance of the material of the coil.

$$\rho = \frac{\pi d^2}{4L} X$$ .... working formula

The values of d, L and X are substituted in the working formula to determine the value of specific resistance ρ.

Observations

1. Data available for the wire

Material = manganin (usually manganin or constantan)

Gauge (S.W.G.) no. = 30 (if known)

Teacher's Signature :

Observations for the diameter of a wire.

No. of observations	Main scale Reading S (cm)	Circular scale div. coinciding n	observed diameter $d_1 = S + na$	Corrected diameter $d = d_0 - e$
1.	0	53	0.53	0.23
2.	0	48	0.48	0.18
3.	0	49	0.49	0.19
4.	0	45	0.45	0.15

Mean corrected diameter (d) = 0.18 mm

mean radius (r) = $d/2$ = 0.9 mm

Actual value of ρ_0 for the material from the tables of constants

$$\rho_0 = 5.45 \times 10^{-8} \text{ ohm-m}$$

Percentage Error in the value of ρ

$$\% \text{ error} = \frac{\rho - \rho_0}{\rho_0} \times 100 = 4.41 \%$$

Precautions

1. The ends of the connecting wires should be rabbed and cleaned with a sand paper. The connections should be neat, clean and tight
2. Plugs in the resistance box should be pressed and tightened by screwing them a little in the clock wise direction.

Sources of Error

1. The wire of the meter bridge may not be of uniform area of cross section throughout its entire length
2. The screw gauge may have backlash error due to loose fitting of its screw.
3. End corrections

Result

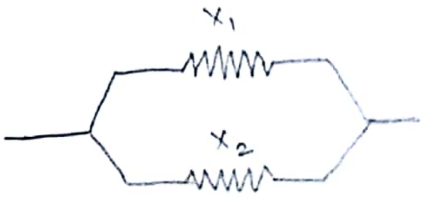
i) within the experimental error, the unknown value of resistance as determined by using a meter bridge is found to be 0.82 ohms

ii) The value of specific resistance of the material of the wire is 5.60×10^{-8} ohm-m with a percentage error of 0.91 % per cent.

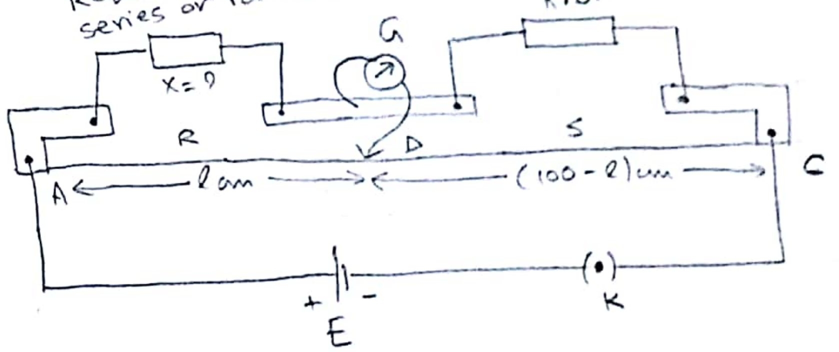
Teacher's Signature : ______________

Aim :- To verify the laws of combination of resistances (in series and parallel) using a metre bridge.

Series Combination



Parallel combination



Circuit diagram for study of the laws of resistances in series and parallel.

Date ....

Expt. No. A - 3, 4 Page No. 13

Aim :- To verify the laws of combination of resistances (in series and parallel) using a metre bridge.

Apparatus - A meter bridge, three different resistances or resistance coils, a resistance box, a jockey, a one-way key, a galvanometer, battery eliminator or a daniell cell, thick connecting wires, sand paper etc.

Theory -

Laws of combination of resistances.

a) Series combination :

Two or more resistances $R_1, R_2, \ldots$ are said to be connected in series if they are connected end to end as shown in fig. a) The equivalent (or the total) resistance of this combination, R_s, between the ends A and D is given as :

$$R_s = R_1 + R_2 + R_3 \ldots$$

b) Parallel combination -

Two or more resistances R_1, R_2, R_3 are said to be connected in parallel when one end of each resistance is connected at one common point say A, and their other ends are connected to another common point say B, as shown in fig The equivalent (or the total) resistance R_p of the combination is given by the relation.

Teacher's Signature :

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots\ldots$$

The equivalent resistance R_p would thus be smaller than the smallest resistance used in the combination. In other words, R_p will be smaller than the smallest of R_1, R_2, R_3 ......

Metre Bridge

The value of an unknown resistance X of a resistor can be determined by using metre bridge as explained in the theory of experiment No. 2 11 is given by the formula

$$X = Q\left(\frac{l}{100-l}\right) \quad \ldots\ldots \text{working formula}$$

The values of given individual resistances X_1, X_2 and X_3 are determined first and thereafter those of the series and parallel combinations.

The constrains on time may not permit the verification of laws by using three resistors so only two resistors may be used.

Observations and Calculations

Verification

Compute the values X_1 X_2 X_s and X_p by substituting the corresponding values of l and Q in the relation

$$X = Q\frac{l}{100-l}$$

Teacher's Signature : ______________

Observations and Calculations

Resistance used	No. of Obs.	Resistance Q (ohm)	Length AD = l	Length DC = 100 − l	Resistance $X = \frac{Q' l}{100-l}$	Mean value of the resistance X (ohm)
X_1	1	2	40.5	59.5	2.93	2.76
	2	4	60.5	39.5	2.61	
	3	5	64.5	35.5	2.25	
X_2	1	2	55	45	1.63	1.73
	2	4	69.6	30.4	1.76	
	3	5	72.0	28	1.94	
X_1 and X_2 in series	1	2	30.2	69.8	4.62	4.79
	2	4	46.0	54.0	4.69	
	3	5	50.5	49.5	4.90	
X_1 and X_2 in parallel	1	2	63.0	37.0	1.17	1.17
	2	4	77.0	23.0	1.19	
	3	5	81	19.0	1.17	

Verifying the law of series combination

compute the value :

a) series resistance by theoretical formula

$$x'_s = x_1 + x_2 = 4.53 \text{ ohm}$$

b) Experimental value of the series combination,

$$x_s = 4.70 \text{ ohm.}$$

within the experimental error, experimental and theoretical values of the series combination of x_1 and x_2 ie x_s and x'_s respectively are almost equal ie. $x_s \approx x'_s$

Hence the law of combination of resistance in series stands verified.

Verifying the law of Parallel combination

compute the value of :

a) Parallel combination by theoretical formula

$$\frac{1}{x'_p} = \frac{1}{x_1} + \frac{1}{x_2}$$

$$\text{or} \quad x'_p = \frac{x_1 x_2}{x_1 + x_2}$$

b) Experimental value of the parallel combination.

$$x_p = 1.17 \text{ ohm}$$

Since, within experimental errors, the experimental value of parallel combination of x_1 and x_2, ie x_p and theoretical value x'_p are equal,

ie $x_p \simeq x'_p$.

so the law of combination of resistances in parallel also stands verified.

Teacher's Signature : ....

Precautions

1. The connecting wires used should be thick copper wires and the insulation of their ends should be removed by rubbing them with a sand paper.
2. Connection should be tight.

Result

1. The values of the individual resistances measured by the metre bridge are:
   x_1 = 2.76 Ω x_2 = 1.73 Ω
2. The equivalent resistance of series combination of x_1 and x_2 is x_s = 4.53 Ω
3. The equivalent resistance of parallel combination of x_1 and x_2 is x_p = 1.17 Ω
4. The value of series combination of x_1 and x_2, $x_1 + x_2$ = 4.53 Ω whereas x_s = 4.79 Ω Since x_s is nearly equal equal to $x_1 + x_2$, the law of series combination of resistance stands verified.
5. The sum of the reciprocals of x_1 and x_2
   $\frac{1}{x_1} + \frac{1}{x_2}$ = 0.94 $(ohm)^{-1}$ whereas $\frac{1}{x_p}$ = 0.94 ohm^{-1}
   or x_p = 1.06 ohm

Since the sum of the reciprocal of x_1 and x_2 ie $\left(\frac{1}{x_1} + \frac{1}{x_2}\right)$ ie x_p' is nearly equal to x_p. their difference $x'_p - x_p$ = 0.106 (ohm) being negligibly small, so, the law of combination of resistances

Teacher's Signature :

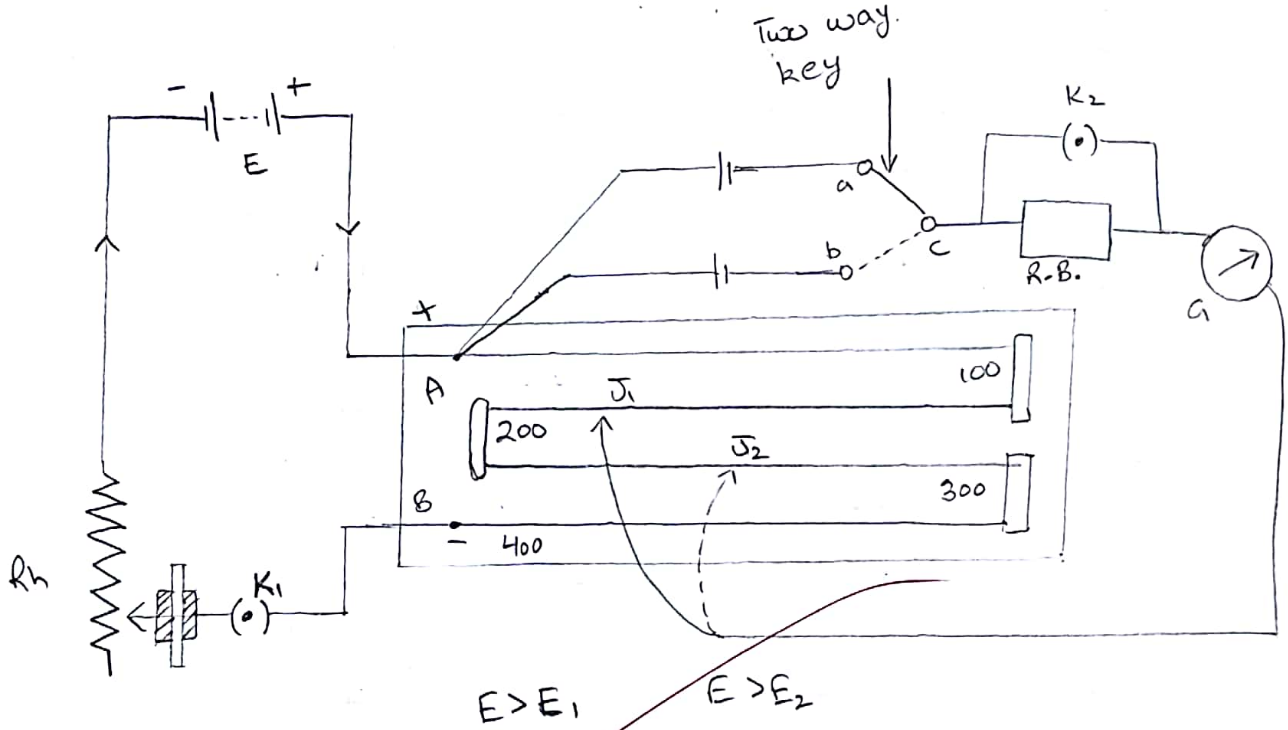
Date

Expt. No.

in parallel stands verified.

Teacher's Signature :

Aim - To compare the e.m.f.s of two given primary cells (Daniel and Lechlanche) using a potentiometer



circuit diagram for comparison of e.m.f.s of two primary cells.

Aim :- To compare the emfs of two given primary cells (Daniell and Lechlanche) using a potentiometer.

Apparatus -
A potentiometer (with 10 wires stretched on the board), with a sliding jockey, two primary cells (Daniel and lechlanche), a one-way key, a plug-type resistance box (0 to 1000Ω), two-way key, a weston type galvanometer, a battery or battery eliminator, a low resistance rheostat about 20Ω, one-way keys meeded will be two, as is clear from K_1 and K_2 in the figure 4.2 ~~conducting~~ connecting wires and sand paper.

Theory
Let the two primary cells whose e.m.f.s are to be compared be so connected in the circuit that their positive poles are joined together to the end A of the potentiometer wire AB and their negative poles are joined to a galvanometer through a two-way key a,b,c. The other terminal of the galvanometer is connected to a jockey J as shown in Fig 4.2. The two primary cells with emf's E_1 and E_2 can be connected in turn to the sliding contact J through the galvanometer G with the help of the two-way key a b c. Let a steady potential difference be maintained (using the battery E and rheostat Rh) across the ends of the wire AB, the end A being at higher potential than the end B.

By closing the gap ac in the two-way key when the cell E_1 is connected in the circuit and by sliding the yockey J, a position of the null deflection in the galvanometer is found at J_1. Let l_1 be the length AJ_1, of the wire.

Teacher's Signature :

Observation Table

No. of Obs.	Balance length when E_1 Lechlanche cell is in the circuit l_1 (cm)	Balance length when E_2, Daniel cell is in the circuit l_2 (cm)	Ratio $\frac{E_1}{E_2} = \frac{l_1}{l_2}$
1.	576	422	1·36
2	569	440	1·293
3.	453	335	1·352
4.	448	333	1·346
5	451	334	1·350
6.	460	340	1·353

Mean value of $\frac{E_1}{E_2}$ = 1·337

Date

Expt. No.

Similarly, on joining the terminals b and c ie. using the cell E_2, the length l_2 is determined for null deflection. Now according to the principle of potentiometer as discussed, we have

$$E_1 = kl_1$$

$$E_2 = kl_2$$

where k is the potential gradient ie drop of potential per unit length

$$\frac{E_1}{E_2} = \frac{kl_1}{kl_2} = \frac{l_1}{l_2}$$

$$\boxed{\frac{E_1}{E_2} = \frac{l_1}{l_2}}$$ working Formula

where E_1 and E_2 are e.m.f.s of the two cells of low internal resistance; l_1 and l_2 are respectively the balancing lengths, when E_1 and E_2 are connected to the circuit.

Observations

1. No. of wires on the potentiometer board = 4
(usually 10 in a good instrument)
2. Range of Voltmeter for observing emfs. of battery and cells = 1 V
3. Least count of the Voltmeter scale = 0·5 V
4. Source of supply of current to auxiliary circuit = ______ (Lead batteries or eliminator)
5. Drop of potential across the battery E = 4 V.
6. Drop of potential across the cell E_1 (Lechlanche) = 2 V
7. Drop of potential across the cell E_2 (Daniell) = 3 V

Teacher's Signature :

Precautions

1. Ensure that emf of battery E is greater than E_1 and E_2 of the cells
2. The wires of the potentiometer should be thoroughly cleaned
3. All the positive terminals should be connected at one point.

Sources of Error

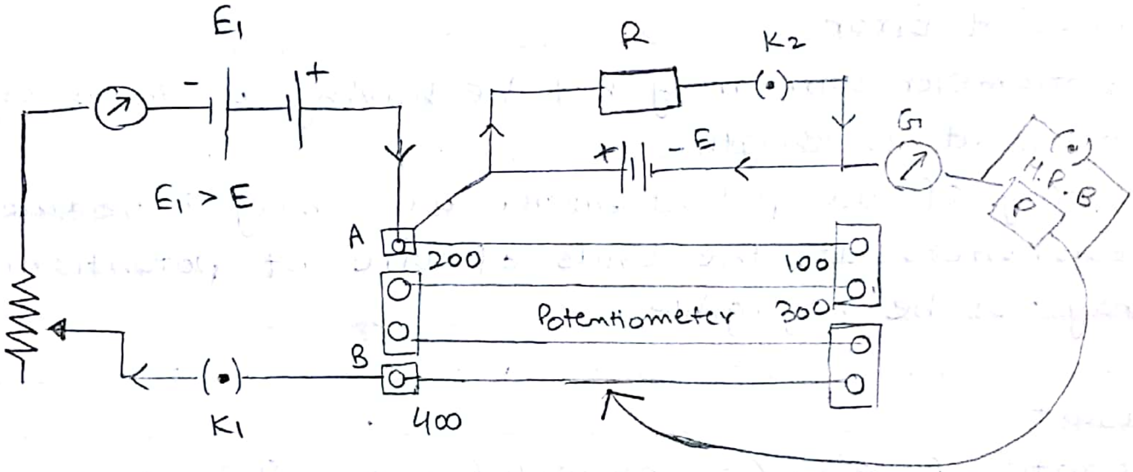
1. Potentiometer wire may not be having uniform cross-section throughout its length
2. Heating of the potentiometer wire may introduce some error.
3. Resistances at the ends of wire of potentiometer may not be negligible

Result

The ratio of e.m.f.s (expected value (1.35 to 1.55)) of E_1/E_2 for Lechlanche cell to Daniell cell = 1.337

Teacher's Signature :

Aim :- To determine the internal resistance of a given primary cell by using a potentiometer.



Internal Resistance of a cell, circuit diagram.

Aim – To determine the internal resistance of a given primary cell by using a potentiometer

Apparatus

A potentiometer, a rheostat, battery eliminator or cells in series (e.m.f. of battery $E > E_1$ of the cell), two one-way keys, a Lechlanche cells, a resistance box (0 to 20 ohms), a R.B. (0 to 200Ω), a jockey, a galvanometer, connecting wires etc.

Theory –

If a cell of emf E and ~~potential~~ internal resistance r, connected to an external resistance R, then the circuit has the total resistance (R+r). The current I in the circuit is given by $I = \frac{E}{R+r}$ $E = I(R+r)$

Hence, $V = IR = E - Ir$

This means, V is less than E by an amount equal to the fall of potential inside the cell due to its internal resistance. From the above equation,

$$\frac{r}{R} = \frac{E-V}{V} \qquad r = R\,\frac{E-V}{V}$$

Using potentiometer, we can adjust the rheostat to obtain the balancing lengths l_1 and l_2 of the potentiometer for open and closed circuits respectively.

Then, $E = kl_1$ and $V = kl_2$, where k is the potential gradient along the wire

Now we can modify the equation for getting the internal resistance of the given cell, by using the above relations as

Teacher's Signature : ____________

Observations

Potential drop across the battery E_1 = 4 volt

Potential drop across the cell E = 2 volt.

No. of Obs	R (ohm)	Balancing length for Lechlanche cell (in cm) — Open circuit when key K_2 open length l_1 (cm)	Closed circuit when key K_2 closed length l_2 (cm)	Internal Resistance $r = R \times \frac{(l_1 - l_2)}{l_2}$ (ohm)
1	10	146.0	112	3.03
2.	10	143.5	118	2.16
3	10	251	193	3.0
4	10	172.5	132.3	3.0

Result -

The internal resistance of the given Lechlanche cell varies with the current drawn from it and its determined value lies between 2.16 and 3.03 ohms

Expt. No. .... Date .... Page No. 22

$$r = \frac{R(l_1 - l_2)}{l_2}$$ ... working formula

Precautions

1. The cell whose internal resistance is to be determined, should not be disturbed during the experiment. The disturbance may alter the internal resistance of the cell
2. As soon as the observations are taken, the plugs K_1 and K_2 should be taken out to avoid too much heating of the potentiometer wire as well as that of the resistance box coils from box P.
3. Ensure that e.m.f. of battery E is greater than E_1 and E_2 of the cells.
4. The wires of the potentiometer should be thoroughly cleaned

Sources of Error

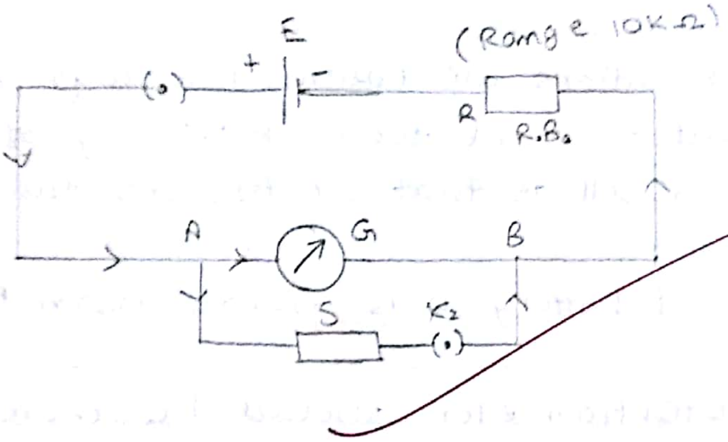
1. Potentiometer wire may not be of uniform area of cross-section throughout its entire length.
2. If the end resistances of potentiometer wire are not taken into account, some error may creep in.

Result

The internal resistance of the given lechlanche cell varies with the current drawn from it and its determined value lies between 2.16 and 3.03 ohms

Teacher's Signature :

Aim - To determine the resistance of a galvanometer by half deflection method



Circuit for determination of resistance of galvanometer by half deflection method

Expt. No. A-7 Date ....

Aim - To determine the resistance of a galvanometer by half deflection method

Apparatus

A weston type galvanometer, a battery or accumulator of 2volt, one resistance box (range 0 to 10,000 ohms) one resistance box (range 0 to 200 ohms), two one-way keys, connecting wires, sand paper etc.

Theory

Resistance of galvanometer by half deflection method.

Here, current will flow through the circuit when key K_1 is closed and K_2 is open. The current flowing through the galvanometer is proportional to the deflection in it.

$$I_1 = \frac{E}{R+G} = K\theta$$

where E - emf of the cell

R - resistance from the resistance box.

G - galvanometer deflection for current I.

K - proportionality constant.

When K_2 is closed and by adjusting the shunt resistance S, we can make galvanometer deflection as $\theta/2$. Then the current in the circuit is

$$I_2 = \frac{E}{R + \frac{GS}{G+S}}$$

Now a fraction, $S/(G+S)$ of the current in the circuit flows through the galvanometer, which is given by.

$$I' = \frac{I_2 S}{G+S} = K\frac{\theta}{2}$$

Teacher's Signature : ____________

Observations

No. of Obs.	Resistance R (ohm.)	Deflection in the galvanometer θ divisions (n)	Half deflection (θ/2) divisions (n/2)	Required shunt S (ohm)	Galvanometer resistance $G = \frac{RS}{R-S}$ (ohm)
1.	10,000	18	9	107	108.15
2.	15,000	12	6	120	120.96
3.	19,000	10	5	130	130.89
4.	7500	24	12	120	121.95

mean value of galvanometer resistance, G = 120.45 ohm

Result

a) Resistance of galvanometer by half deflection method, G = 120.45 ohm

Now from the above relations, we can get the resistance of the galvanometer as

$$G = \frac{RS}{R-S}$$

Precautions and Sources of Error

1. All the connections should be neat and tight. All the plugs in resistance boxes should also be tight.
2. A high resistance ≃ 10 kΩ from the resistance box R should be introduced first and then the battery key K_1 should be closed to avoid any damage to the galvanometer.
3. Deflection in the galvanometer should be as large as possible and should be an even number of divisions.

Result

a) Resistance of galvanometer by half deflection method, G = 120.45 ohm

Aim :- To find figure of merit of a galvanometer and hence the current for full scale deflection.

No. of Obs.	E.M.F. of the cell E (Volt)	Resistance in R.B. R (ohm)	Deflection in the galvanometer (No. of scale divisions) (n)	figure of merit $k = \frac{E}{(R+G)\,n}$ (amp / division)
1.	2	7500	24	1.093×10^{-5}
2.	2	9000	20	1.096×10^{-5}
3.	2	9900	18	1.108×10^{-5}
4.	2	15000	12	1.102×10^{-5}

Mean value of k = 1.01×10^{-5} ampere / division

Date ....

Expt. No. 4-8 Page No. 25

Aim - To find ~~its~~ figure of merit of a galvanometer and hence the current for full scale deflection

Apparatus

A weston type galvanometer, a battery or accumulator of 2volt, one resistance box (range 0 to 10,000 ohms), one resistance box (range 0 to 200 ohms), two one-way keys, connecting wires, sand paper etc.

Theory

Figure of merit of a galvanometer

Figure of merit is in general the numerical value representing the degree of effectiveness or efficiency of an instrument approximated by different estimation techniques

The figure of merit of a galvanometer is the current required to produce a deflection of one division in the galvanometer scale. It is represented by the letter k, and is given as, $k = \frac{I}{\theta}$

$$k = \frac{E}{(R+G)\,\theta}$$

Observations

1. Resistance of the galvanometer (G) by half deflection method = 120.45 ohm
2. E.M.F. of the cell or battery eliminator, E = 2 volt.
3. Total number of divisions ~~can~~ on either side of the zero of the galvanometer scale,

Teacher's Signature :

No = ...30.... (usually 30)

Precautions and Sources of Error

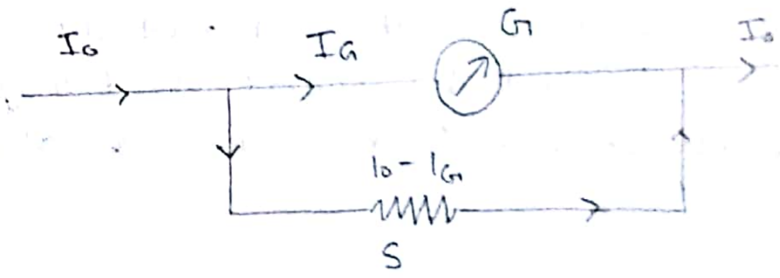
1. E.m.f. of the battery or eliminator used should be constant. If the battery is used it should be freshly charged.
2. Value of R must be very large as compared to the value of G, other wise the result will not be satisfactory
3. All the connections should be neat and tight. All the plugs in resistance boxes should also be tight.

Result

Figure of merit, k = 1.01×10^{-5} amp/division

Current I_g for full scale deflection = 3.03×10^{-4} ampere

Aim – To convert the given galvanometer (of known resistance and figure of merit) into an ammeter of a desired range and to verify the same



Principle of an ammeter.

A shunt, $S = \frac{I_G}{I_0 - I_G} \times G$

connected in parallel with galvanometer

Aim - To convert the given galvanometer (of known resistance and figure of merit) into an ammeter of a desired range and to verify the same

Apparatus
A weston type galvanometer whose resistance and figure of merit are given. A constantan or manganin wire of 26 or 30 s.w.g. diameter, a screw gauge, wire cutter, a battery or an accumulator of 2V, a one-way key, a rheostat of range about 200Ω, a mili-ammeter of 30mA range, connecting wires and sand papers etc.

Theory
A galvanometer can detect only small currents, Thus to measure large currents it is converted into an ammeter It can be converted into an ammeter by connecting a low resistance called shunt resistance in parallel to the galvanometer.
Let G be the resistance of the galvanometer and I_g be the current for full scale deflection in the galvanometer, the value of the shunt resistance required to convert the galvanometer into an ammeter of 0 to I ampere is

$$S = \left(\frac{I_g}{I - I_g}\right) G$$

I_g is ~~use~~ calculated using the equation, $I_g = nk$ where n is the number of divisions on the galvanometer and k is the figure of merit of galvanometer.

Teacher's Signature : ____________

Observation

S.No.	Resistance	Deflection in Galvanometer	Short Resistance	half deflection	$G = \frac{RS}{R-S}$
1.	4000	14	52	7	52.56
2	5500	10	55	5	55.68
3	7000	8	55	4	55.47

Observations

1. Given resistance of galvanometer $G = 120.45\ \Omega$
2. Given value of figure of merit $k = 1.01 \times 10^{-5}$ amp/div.
3. Total number of division on either side of zero, N_0 = 30

4. Current for full scale deflection,
$I_G = N_0 \times k = 3.03 \times 10^{-4}$ amp.

a) Calulation of the value of shunt resistance
5. Required range of the converted ammeter
$I_0 = 1 \times 10^{-3}$ amperes
6. Value of the shunt resistance,
$$S = \frac{I_G}{I_0 - I_G} \times G = 55 \text{ ohms}$$

7. Observations for the diameter of the wire
i) Pitch of the screw gauge (p) = 1 mm ~~cm~~
ii) No. of divisions on circular scale = 100
iii) Least count (a) = 0.01 cm
iv) Zero error (e) = 0.3 mm ~~cm~~
v) Zero correction (−e) = −0.3 mm ~~cm~~

8. Specific resistance of the material of the wire,
ρ = ~~oh~~ 44×10^{-6} ohm-cm (ρ for manganin, $44 \times 10^{-6}\ \Omega$ m)
for constantan, $49 \times 10^{-6}\ \Omega$ cm)
9. Required length of the wire,
$$l = \frac{S \times \pi d^2}{4\rho} = 3 \times 27 \times 10^{-5} \text{ cm}$$
$= 27.22$ cm

Teacher's Signature : ....

Precaution and Sources of Error

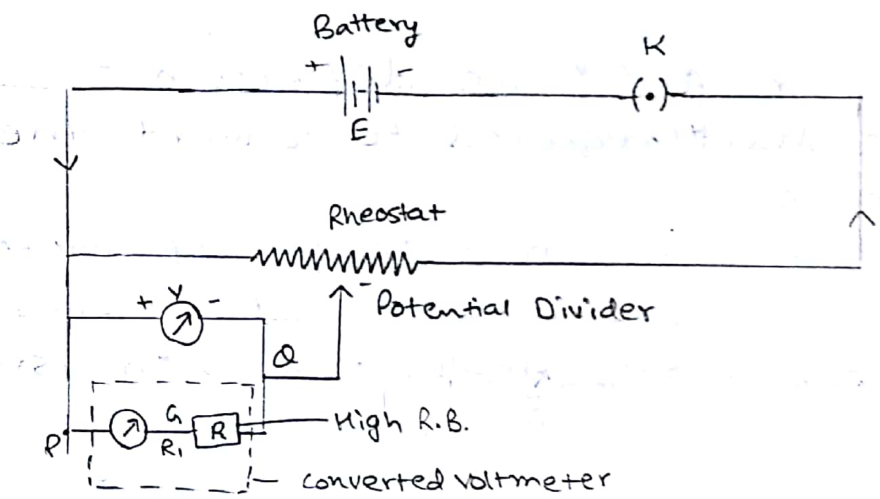
1. All the connections should be neat and tight
2. The length of the shunt wire should be neither too large nor too small (optimum length 50 to 60 cm.)
3. While connecting the shunt across the galvanometer care should be taken to see that only the exact required length of wire l lies between the binding screws. So a wire of length longer by 2cm/ than l should be selected so that the extra length lies below the terminals of the galvanometer.

Result -

a) Current I_G for full scale deflection = 3.83×10^{-4} amperes
b) Value of the shunt required to convert the galvanometer, ie $S =$ 55 ohms. Required length of material manganin s.w.g. wire = 27.22 cm

As error $I' - I$ is very small, conversion is verified

Aim :- To convert the given galvanometer (of known resistance and figure of merit) into a voltmeter of desired range (say 0 to 3V) and verify the same.



A galvanometer converted into an Voltmeter

Aim :- To convert the given galvanometer (of known resistance and figure of merit) into a voltmeter of desired range (say 0 to 3V) and verify the same.

Apparatus

A weston type galvanometer whose resistance and figure of merit are given. A resistance box of range 0 to 10k Ω, a battery or accumulator of 5V (minimum potential drop equal to the desired range) a rheostat (of range 200 Ω) to be used as potential divider arrangement, a one-way key, a voltmeter (0 to 3V) for comparing the accuracy of the converted voltmeter, connecting wires, sand papers etc.

Theory

Conversion of a galvanometer into a voltmeter

A high resistance of suitable value is connected in series with the galvanometer to convert it into a voltmeter.

Voltmeter is always connected in parallel with the circuit.

If the converted galvanometer is desired to have a range of V_0 volts, then the total resistance R_1 that must be included in the circuit for a current of I_a amp. is given by

$$R_1 = \frac{V_0}{I_a} \text{ ohms}$$

Since the resistance of the galvanometer is G ohms

Teacher's Signature : ....

Observation

S.No.	Voltage Reading (V)	V × L.C.	Galvanometer Reading (G)	G × L.C.	diff.
1	16	0.80	80	0.80	0
2	18	0.90	92	0.92	0.02
3	14	0.70	70	0.70	0
4	19	0.95	96	0.96	0.01
5	12	0.60	60	0.60	0

the additional resistance R that should be placed in series with the galvanometer is given as

$R_1 = R + G = V_0 I_G$

$R = \left(\frac{V_0}{I_g} - G\right)$ ohms

Observations

1. Given resistance of the galvanometer, $G = 120.45$ ohms
2. Given value of the figure of merit, $k = 1.01 \times 10^{-5}$ amp/div.
3. The total number of divisions on either side of the zero of the galvanometer, $N_0 = 30$
4. Current required for producing full scale deflection of N_0 divisions,

$I_G = k . N_0 = 3.03 \times 10^{-4}$ amperes

a) calculations of the value of resistance R for placing in series with the galvanometer

5. Required range of the converted voltmeter = 12-16 volts
6. Value of the required series resistance,

$R = \frac{V_0}{I_G} - G = 52,024$ ohms

b) verification.

7. Voltage indicated by full scale deflection (N_0) of the converted voltmeter = 16 volts
8. least count of the converted voltmeter

$k' = \frac{V_0}{N_0} =$ volts / div.

Teacher's Signature : ....

Date ....

Expt. No. .... Page No. 32

Precautions and Sources of Error

1. Calculations for the required series resistance for conversion, should be done carefully.
2. One free terminal of the resistance box and the other free terminal of the galvanometer are the terminals of the converted voltmeter.
3. Any zero error in the galvanometer or voltmeter should be eliminated or accounted for.

Result

For the given galvanometer of resistance, $G = 120.45$ ohms and figure of merit, $k = 1.01 \times 10^{-5}$ A (div)$^{-1}$

a) Current for full scale deflection $I_g = 3.03 \times 10^{-4}$ A

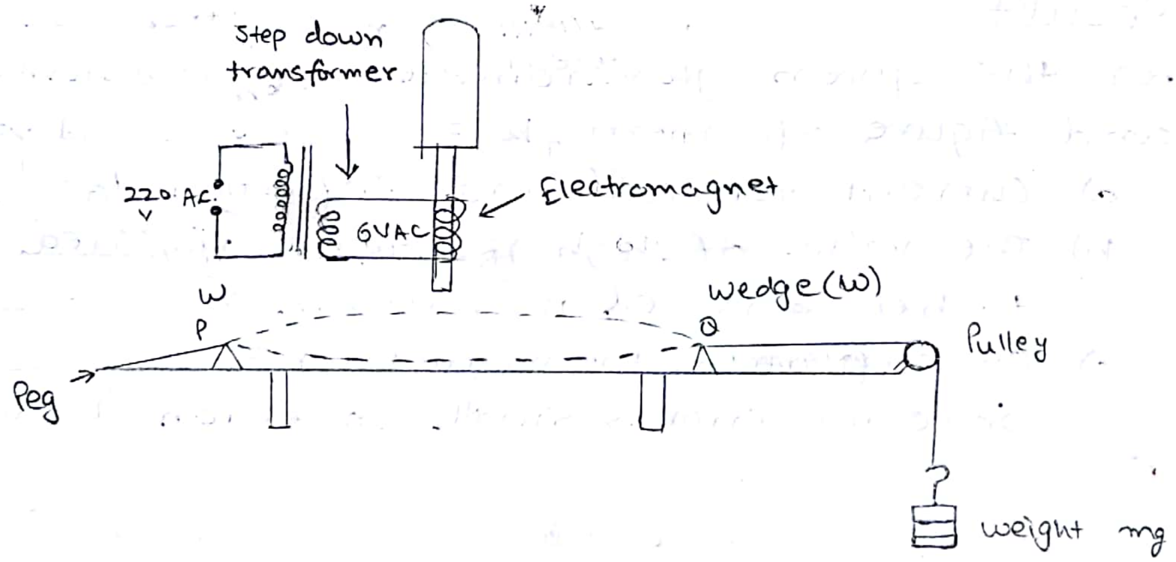
b) The value of high resistance required to be connected in series $R = 52{,}024$ ohms

c) On verification, the mean error = 0.018 %

Since the error is small, conversion is verified.

Teacher's Signature : ____________

Aim :- To find the frequency of an alternating current (a.c.) mains by sonometer and an electromagnet



Set up for finding the frequency of a.c mains using an electromagnet and a sonometer.

Aim - To find the frequency of an alternating current (a.c.) mains by sonometer and an electromagnet

Apparatus

A sonometer with soft iron stretched over it, an electromagnet, a step-down transformer, slotted half kilogram, a hanger, a physical balance and a weight box.

Theory

Let a wire of length l and mass per unit length m be stretched by applying a force T called the tension in the string. If it is set into transverse vibrations in fundamental mode, then the frequency ν of the note emitted by it is given by

$$\nu = \frac{1}{2l}\sqrt{\frac{T}{m}}$$

If the length l and tension T in the wire are so adjusted that it is set into resonant vibrations by the a.c. then the frequency of a.c. will be half that of the frequency of vibration of the wire. If ν is the frequency of the sonometer wire thrown into resonant vibrations in fundamental mode then the frequency of a.c. ~~will be~~ would be $f = \frac{\nu}{2}$ cycles/sec or $\nu/2$ hertz.

Observations

Length of the wire (L) = 100 cm
Mass of this length (m') = 0.15 g
Mass per unit length (m) = $\left(\frac{m'}{L}\right)$ = 0.0015 g/cm
= 1.5×10^{-4} kg/m

Teacher's Signature : ____________

No. of obs	load (m) (including mass of hanger)	Tension T = Mg (newton)	Resonant length l (cm)			$\nu = \frac{1}{2l}\sqrt{\frac{T}{m}}$
			1	2	mean l (cm)	
1.	1.5	14.7	52.9	47.2	50.05	100
2	2	19.6	50.5	48	49.25	105
3	2.5	24.5	55.5	51.3	55.5	97

mean value of ν = 100.66 hertz.

Result -

Frequency of a.c. mains (f) as determined by sonometer f = 50.33 cycles/sec. or Hz.

Standard value of a.c. mains in India (f_0) = 50 cycles/sec.

Percentage error = $\left(\frac{f - f_0}{f_0}\right) \times 100$ = 0.66 %

value of (acceleration due to gravity) g = 9·8 m/s²

Calculations

For each set of observations, calculate the value ν find their mean

The frequency of a.c. supply, (f) = $\frac{\text{mean value of } \nu}{2}$

Precautions

1. The sonometer wire should be of magnetic material, free from kinks and stretched horizontally
2. The pole of the electromagnet should be held quite close to the middle of the vibrating segment.
3. The position of maximum amplitude should be judged at least twice for each load.

Sources of Error

1. The relation $\nu = \frac{1}{2l}\sqrt{\frac{T}{m}}$ has been derived under the condition that the wire is perfectly flexible. Hence an error may creep in due to rigidity of the wire.
2. The wire may not be of uniform area of cross-section, Its composition may not be uniform

Result

Frequency of a.c. mains (f) as determined by sonometer,

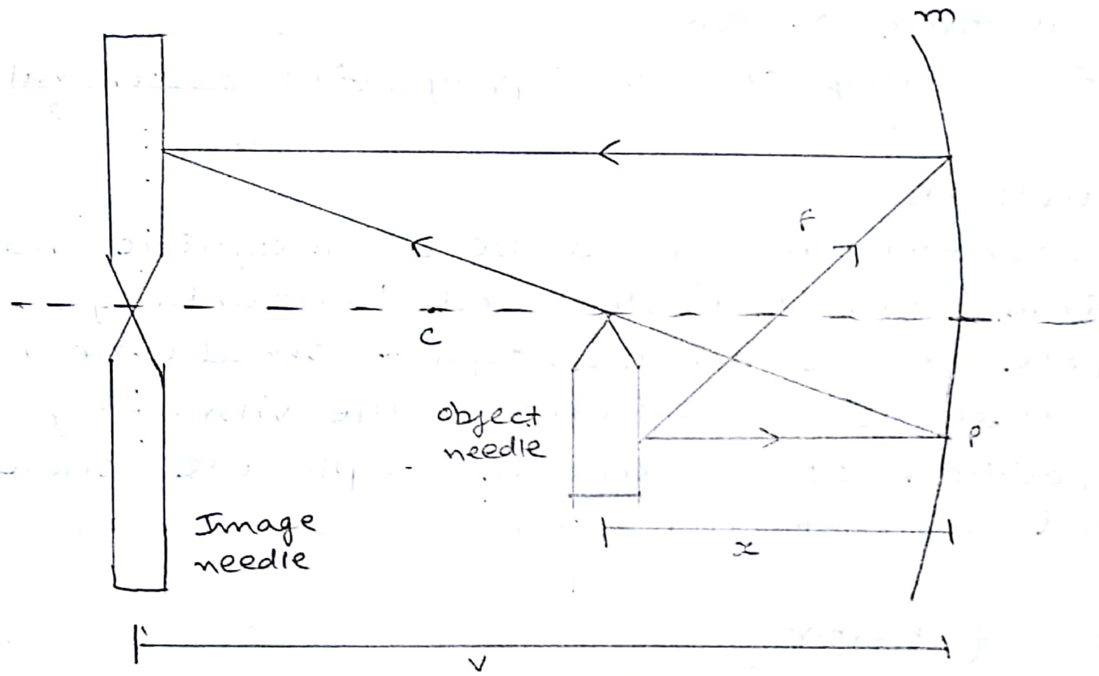
f = ~~eg~~ 50·33 cycles/sec. or Hz.

standard value of a.c. mains in India (f_0) = 50 cycles/s.

Percentage error = $\left(\frac{f - f_0}{f_0}\right) \times 100$ = 0·66 %

Teacher's Signature :

Aim :- To find the value of v for different values of u in case of concave mirror and to find the focal length.



focal length of a concave mirror

S.No.	Position of (cm)		object	Image	1/u	1/v
	Needle (O)	Image (I)	distance u	distance v	(cm⁻¹)	(cm⁻¹)
1	23	42	-23	-42	0.042	0.023
2	25	38.2	-25	-38.7	0.040	0.025
3	30	32	-30	-32	0.033	0.031
4	35	27.5	-35	-27.5	0.028	0.036
5	40	24	-40	-24	0.025	0.042
6	45	22.3	-45	-22.9	0.022	0.044

mean value of f = 16 cm

Date ....

Expt. No. B-1 Page No. 35

Aim - To find the value of v for different values of u in case of concave mirror and to find the focal length.

Apparatus

An optical bench along with three uprights, one mirror holder, two needles, concave mirror, a knitting needle and a metre scale.

Theory

The relation between the object distance u, the image distance v and the focal length f of a concave mirror is given as.

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

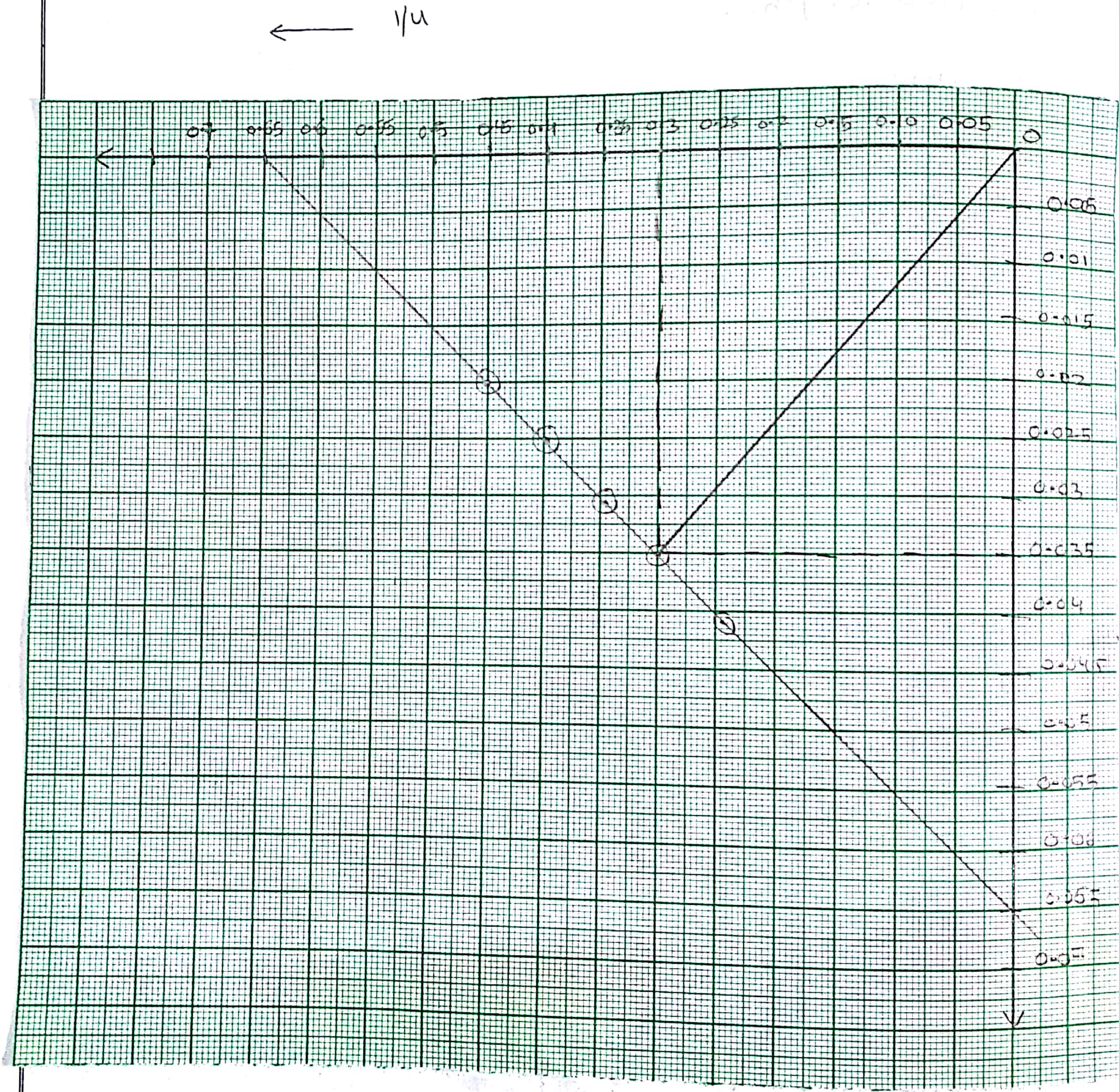
$$f = \frac{uv}{u+v}$$

Observations

1. Rough focal length of the concave mirror = 15 cm
2. Length of the knitting needle, x = 22.5 cm
3. Observed distance between the mirror and the object needle O when the knitting needle is introduced in between them, y = 22 cm
4. Observed distance between the mirror and the image needle I when knitting needle is introduced in between them z = 23 cm
5. Index error for u, $e_1 = (y - x) = 22 - 22.5 = -0.5$ cm

   Index correction for u, $= (-e_1) = 22.5 - 22 = 0.5$ cm

Teacher's Signature : ____________


1/u

6. Index error for v, $e_2 = (z-x) = 22.5 - 23 = -0.5$ cm
Index correction for v, $= (-e_2) = 23 - 22.5 = 0.5$ cm

Precautions

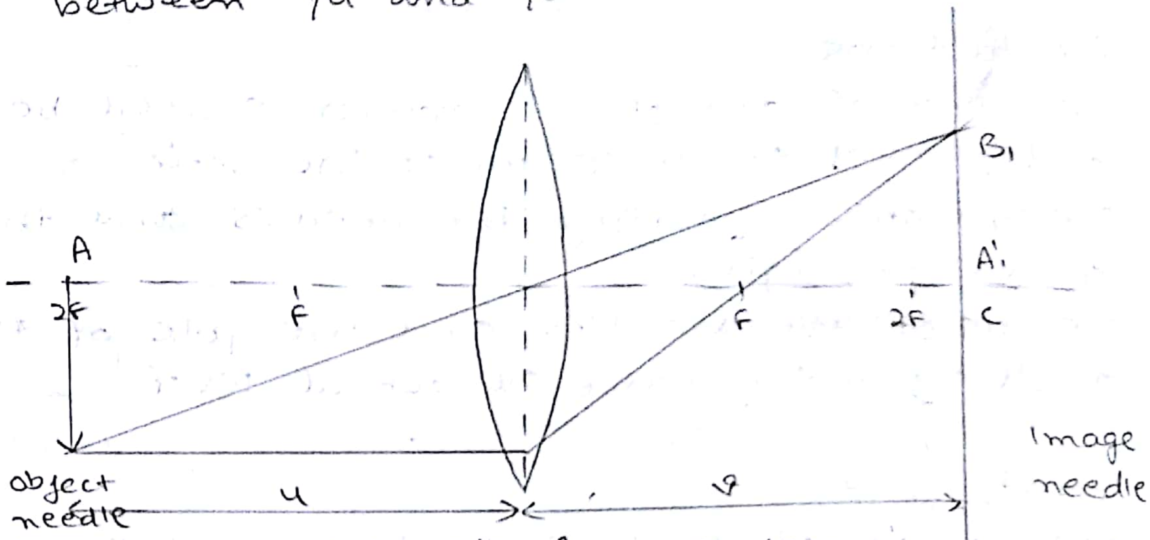
1. The principal axis of the mirror should be horizontal and parallel to the length of the scale.
2. The uprights supporting the needles and the mirror should be rigid.
3. The tips of the meedles and the pole of the mirror should be at the same horizontal level.

Result

Mean value of focal length by computation = 16 cm
Focal length of the given concave mirror as determined from the graph

1. $(u-v)$ (hyperbola) $f = -15.5$ cm
3. $\left(\frac{1}{u} \text{ vs } \frac{1}{v}\right)$ straight line $f = -15.625$ cm

Aim :- To find the focal length of a convex lens by plotting graphs between u and v or between 1/u and 1/v



Focal length of convex lens

S.No.	Position of			u	v	1/u	1/v
	lens	object	Image				
1	50	31.4	70.8	18.6	20.8	0.053	0.048
2	50	30	68.5	20	18.5	0.05	0.054
3	50	28	66.9	22	16.9	0.045	0.059
4	50	25	66.3	25	16.3	0.04	0.061
5	50	21	65	29	15	0.034	0.067
6	50	17	63.6	33	13.6	0.03	0.073
7	50	13	63	37	13	0.027	0.077

Rough focal length of convex lens = 9.2 cm

OA = OB = 19 cm = 2f

$f = \frac{19}{2} = 9.5$

Aim - To find the focal length of a convex mirror using a convex lens

Apparatus

An optical bench with four uprights, a convex mirror, a convex lens, a knitting needle and a half - metre scale

Theory

The focal length of a convex mirror can be determined by introducing a convex lens between the object and the convex mirror. An image can be obtained with the help of a convex lens side by side with the object when the convex mirror reflects the rays along the same path, ie, when the rays ~~are~~ fall normally on the mirror. Then, the radius of curvature R, of the mirror is the distance between the screen and the mirror.

The focal length f of the convex mirror is calculated using the formula,

$$f = \frac{\text{Radius of Curvature (R)}}{2}$$

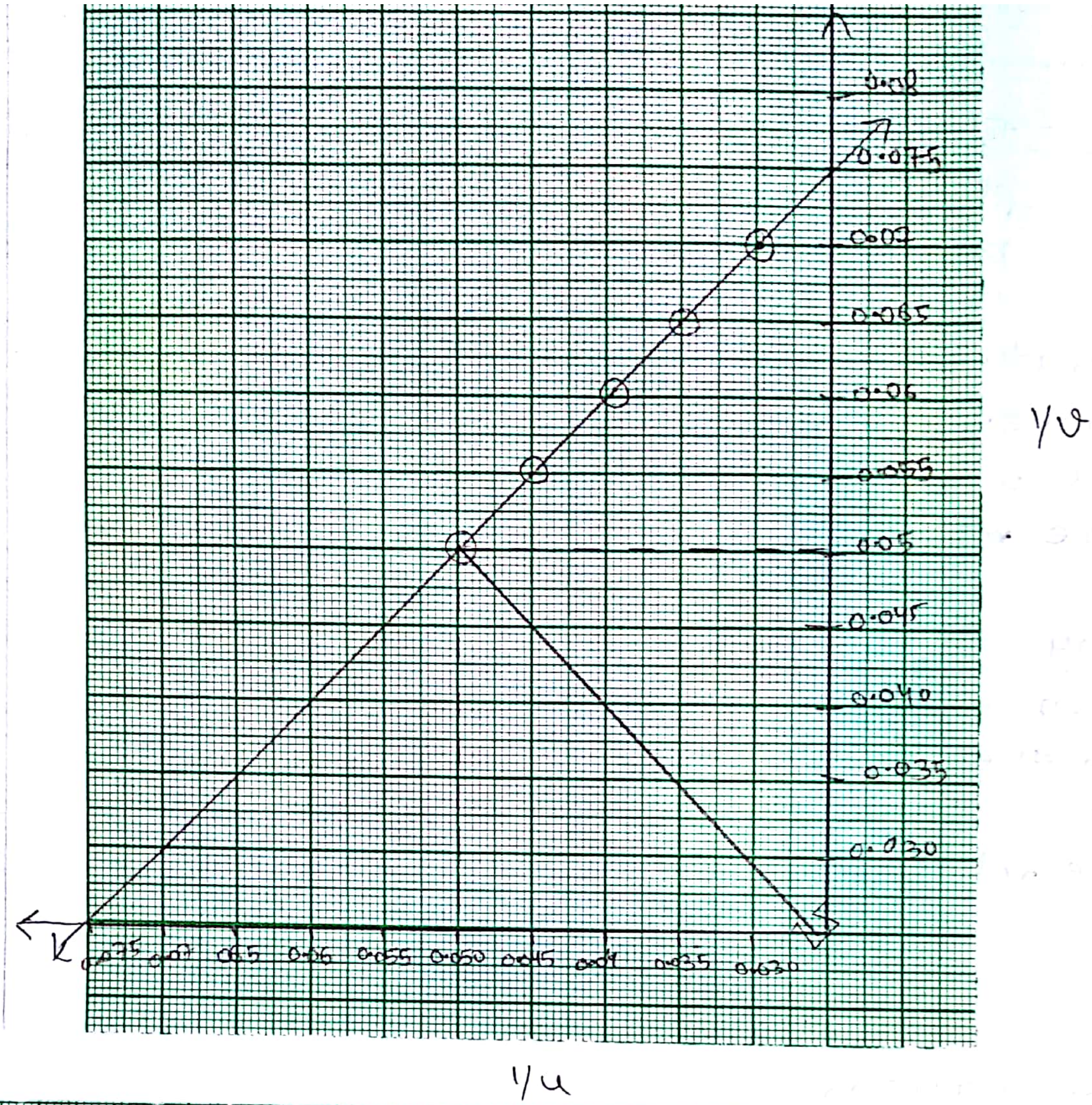
Observations and calculations

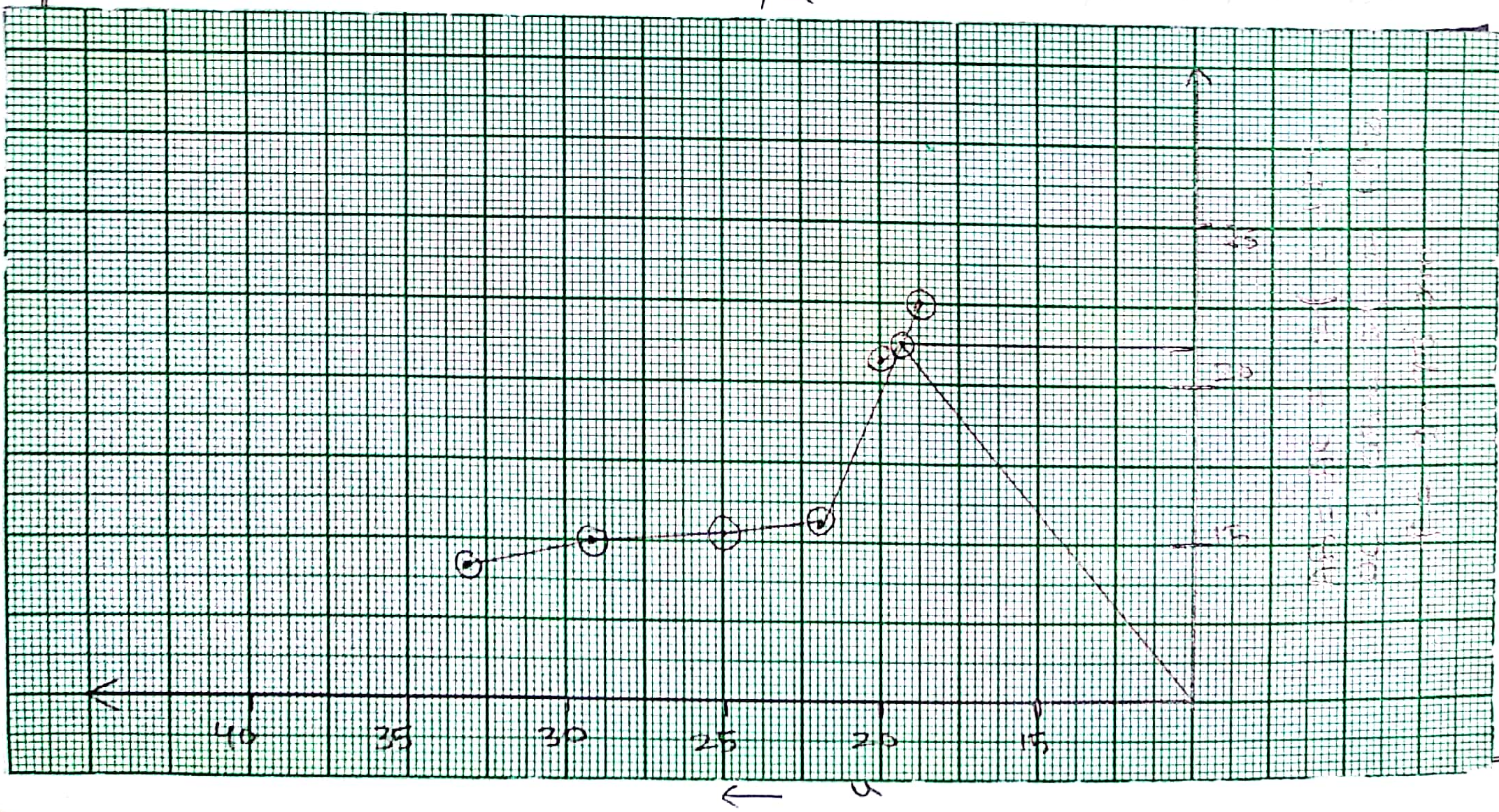
Index correction

length of the knitting needle $y = 22.5$ cm

Observed distance with the needle $x = 22$ cm

between M and I,


1/v
1/u


40
35
30
25
20
15
u

b) for v

4. Observed distance between the image needle and the lens when knitting needle is inserted between them, z = 23 cm
5. For index error for v $e_2 = (z-x) = 22.5 - 23 = -0.5$ cm
6. Index correction for v $(-e_2) = x - z = 23 - 22.5 = 0.5$ cm

Precautions

1. The tips of the needles should be as high as the optical centre of the lens.
2. Parallax should be removed tip to tip
3. The eye should be placed at such a position that the distance between the image needle and the eye is more than 25 cm

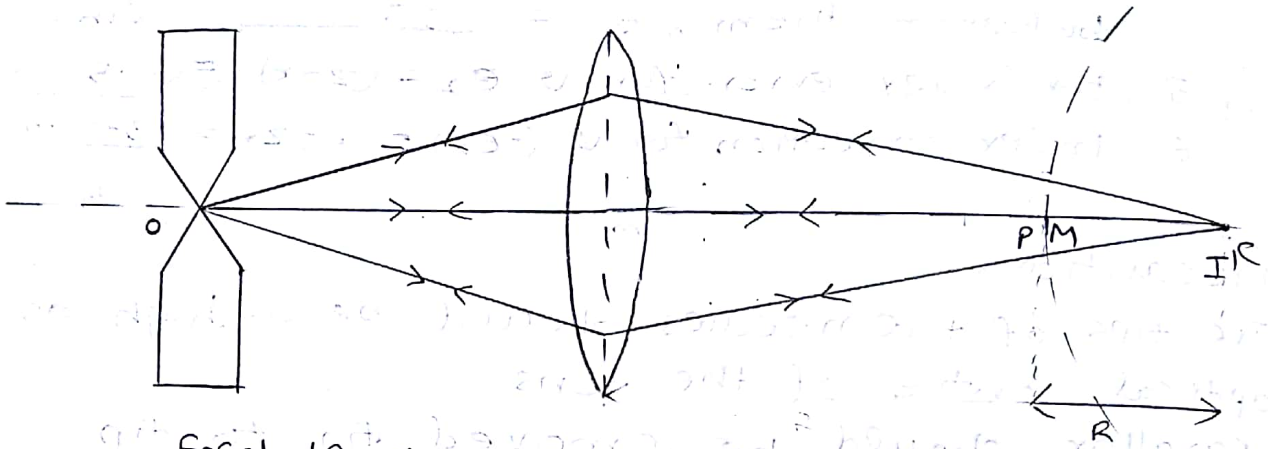
Result

Focal length of the given convex lens as determined from the graph of

i) (u, v) = 10 cm
ii) (u, v) = 10 cm
iii) $\left(\frac{1}{u}, \frac{1}{v}\right)$ = 10 cm

Teacher's Signature :

Aim – To find the focal length of a convex mirror using a convex lens.



focal length of convex mirror

S.No	Position of object (O)	Position of lens (l)	Position of mirror	Position of image	M.I.
	39.8	53.9	60.4	90.5	30.8
	40.4	53.9	65.0	97.4	32.4
	40.1	53.9	62.0	96.1	33.1
	40.6	53.9	64.2	98.3	34.8
	41.3	53.9	62.6	99.4	33.4

mean MI $= \frac{164.3}{5} = 32.9$

Expected distance MI = 32.4

$f = \frac{\text{corrected MI}}{2} = \frac{32.9 - 0.5}{2} = 16.2$ cm

Aim – To find the focal length of a concave lens, using a convex lens.

Apparatus

A concave lens, a convex lens of focal length smaller than that of the concave lens (i.e., power of convex lens should be more than that of the concave lens), an optical bench with four uprights and two needles, a knitting needle and a half metre scale.

Theory

Since a concave lens will not produce a real image, a convex lens is used to measure its focal length. There are two methods to find the focal length of a concave lens.

a) Lens in contact method.

When a concave lens of focal length f_2 is placed coaxially in contact with a convex lens of focal length f_1 and if F is the focal length of the combination, then,

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$$

Therefore, the focal length of the concave lens

$$f_2 = \frac{F \times f_1}{f_1 - F}$$

b) Lens out of contact method

The real image (I_1) formed by the convex lens will act as the virtual object for the concave lens. When concave lens is interposed between the convex lens and the real image I_1, the new real image is formed at I_2. If u is the distance of the concave lens from the virtual object I_1 and v is the distance of the concave lens from the real image I_2, then the focal length of the given concave lens is,

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

$$f = \frac{uv}{u-v}$$

Observations

For index correction:

Actual length of the knitting needle x = 22.5 cm

a) For u

1. observed distance between the object needle and the lens when the needle is inserted between them y = 22 cm
2. Index error for u $e_1 = (y-x) = 22-22.5 = -0.5$ cm
3. Index correction for u $(-e_1) = (x-y) = 22.5-22 = 0.5$ cm

b) For v

4. observed distance between the image needle and the lens when the knitting needle is inserted between them z = 23 cm
5. Index error for v $e_2 = (z-x) = 22.5-23 = -0.5$ cm
6. Index correction for v $(-e_2) = (x-z) = 23-22.5 = 0.5$ cm

Calculations

Substitute the values of u and v in the formula

$$f = \frac{uv}{u-v}$$

and calculate f for each observation. Compute the mean value of f.

Teacher's Signature : ____________

Precautions

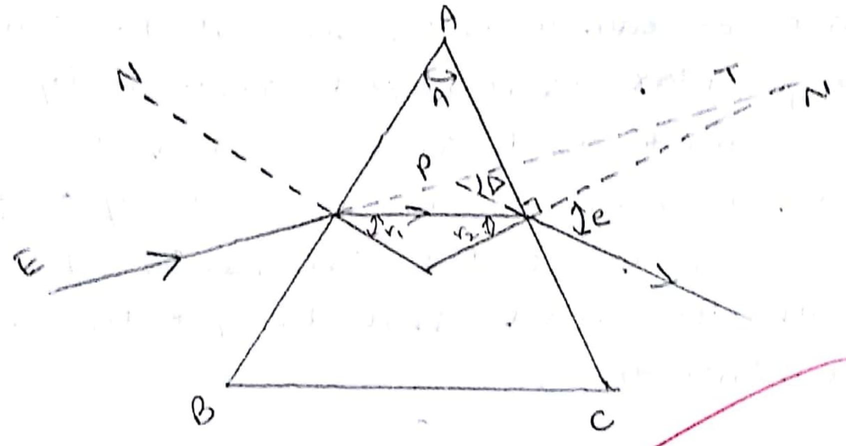
1. The convex lens L_1 should have focal length smaller (ie more power) than that of the given concave lens
2. while looking for the image formed by the combination the field view becomes narrow and the image gets magnified. The concave lens L_2 should be suitably placed so that the parallax is removed accurately
3. Sometimes a faint real and inverted image of the image needle I may also be formed by reflection from the concave surface of the lens L_2. It should not be confused with the bold and bright image formed by the lens combination.

Result

The focal length of the given concave lens = 20·1 cm

Teacher's Signature :

Aim - To determine the angle of minimum deviation for a given glass prism by plotting a graph between the angle of incidence and the angle of deviation



Refraction of light through a prism

Aim – To determine the angle of minimum deviation for a given glass prism by plotting a graph between the angle of incidence and the angle of deviation.

Apparatus

A drawing board, a sheet of paper, glass triangular prism pins, a half-metre scale, a graph paper and a protractor.

Theory

The angle through which the emergent ray deviates from the direction of incident ray is called angle of deviation 'd'.

~~The angle through which the emergent ray deviates from the direction of incident ray is called angle of deviation 'd'.~~

As the angle of incidence is increased, angle of deviation 'd' decreases and reaches minimum value. If the angle is further increased, the angle of deviation is increased.

When a prism is so placed with respect to the incident ray that the angle of deviation produced by it is minimum, then the prism is said to be in the position of minimum deviation. In this position, the following relation holds between the angles,

$$\angle i = \angle e \quad \text{and} \quad \angle r_1 = \angle r_2$$

In this position, the incident ray and the emergent ray are symmetrical with respect to the prism and with the prism the ray travels parallel to its base. The refractive index of material of prism is given as,

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

Teacher's Signature : ____________

Observation

S.No.	Angle of Incidence $\angle i$	Angle of deviation $\angle D$ (δ)
1	30°	40
2	40	37.5
3	45	37
4	55	38
5	60	40

$\angle$ of prism = 60° A = $\angle$ of prism

Calculations -

$$\mu = \frac{\sin\left(\frac{A+D_m}{2}\right)}{\sin(A/2)} = \frac{\sin\left(\frac{60^\circ+37^\circ}{2}\right)}{\sin 30^\circ}$$

$$= \frac{\sin(48.5)}{1/2}$$

$$\mu = 1.37$$

Date ....

Expt. No. .... Page No. 45

where Dm is the angle of minimum deviation and A is the angle of the prism.

Calculations

Angle of prism (A) = 60°

From graph, angle of minimum deviation D = 37°

Refractive index of the material of the prism

$$n = \frac{\sin\left(\frac{A+D}{2}\right)}{\sin \frac{A}{2}}$$

Result

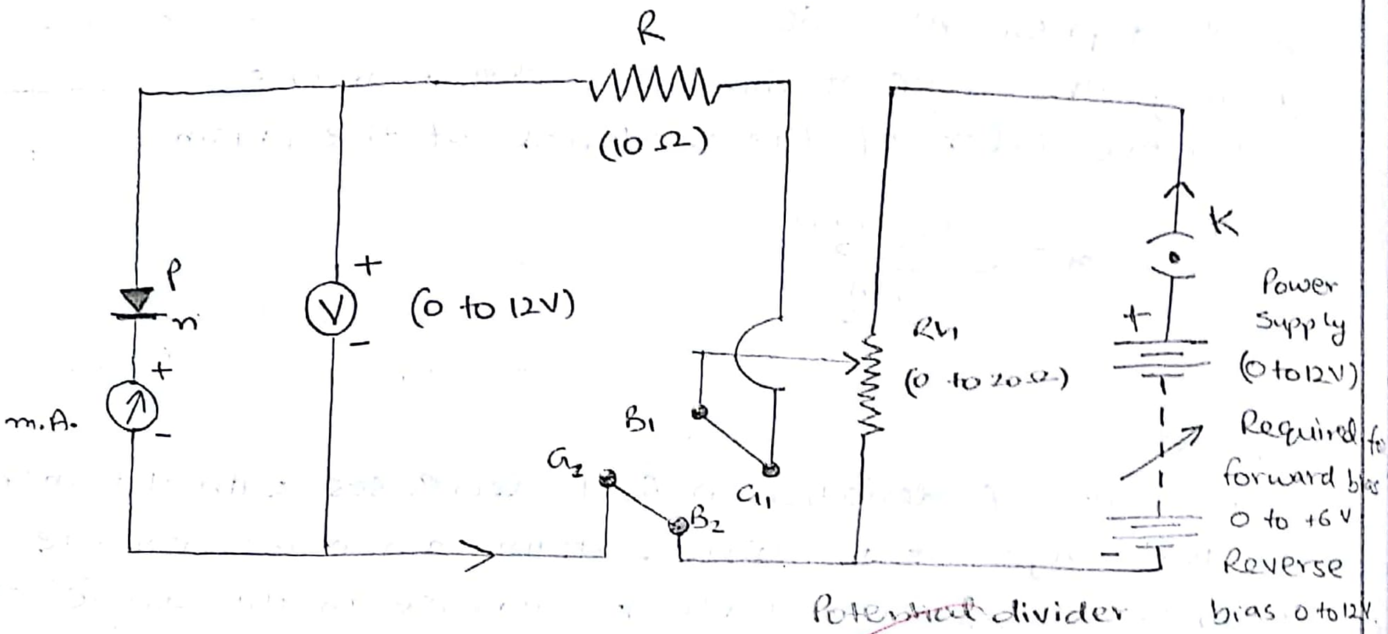
i) The angle of deviation D first decreases with the increase in the angle of incidence, attains a minimum value and then increases with further increase in the angle of incidence as indicated in the (D-i) graph.

Precautions

1. A sharp pencil should be used for drawing the boundary of the prism.
2. The distance between the pins should not be less than 8 cm.
3. The angle of incidence should lie between 30° and 60°.
4. Proper arrows should be drawn to indicate the incident, the refracted and the emergent rays.

Teacher's Signature : ....

Aim - To draw I-V characteristic curve of a p-n junction in forward bias and reverse bias.



circuit diagram for studying the characteristics of a p-n silicon diode. In forward biasing

Aim - To draw I-V characteristic curve of a p-n junction in forward bias and reverse bias

Apparatus
One p-n junction (semi conductor diode), a battery of 6V a rheostat of resistance 20Ω or 30Ω to be used in potential divider arrangement, a resistance of 10Ω, a d.c milliammeter (0 to 30mA and least count 0.5 mA), a d.c. voltmeter (0 to 3V range and least count 0.05 volt), a micro ammeter (0 to 500μA) and a d.c. voltmeter (0 to 12V), connecting wires etc.

Theory
A P-N junction is known as semiconductor diode or crystal diode. It is the combination of P-type and N-type semiconductor. Which offers Nearly zero resistance to current on forward biasing and nearly infinite resistance to the flow of current when in reverse biased.

Forward biasing : when p-type semiconductor is connected to the +ve terminal and N-type to -ve terminal of voltage source Nearly zero resistance is offered to the flow of current.

Reverse biasing : when P-type semiconductor is connected to the -ve terminal and N-type to +ve terminal. ~~Zero~~ Nearly zero current flow in this condition.

Observations
Diode used p-n junction diode
Specifications :
i) Maximum current or current rating = ______ mA.

Teacher's Signature : ______

Observation

p-n forward Bias

S.No.	Voltmeter reading V_f (Volt)		Ammeter reading I_f (mA)	
	n_1	$n_1 \times L.C.$	n_2	$n_2 \times L.C.$
1	6	0.25	0	0
2	10	0.5	0	0
3	15	0.75	3	0.6
4	20	1	7	1.4
5	25	1.25	12	2.4
6	30	1.5	17	3.4
7	35	1.75	22	4.4
8	40	2	27	5.4

p-n reverse biased

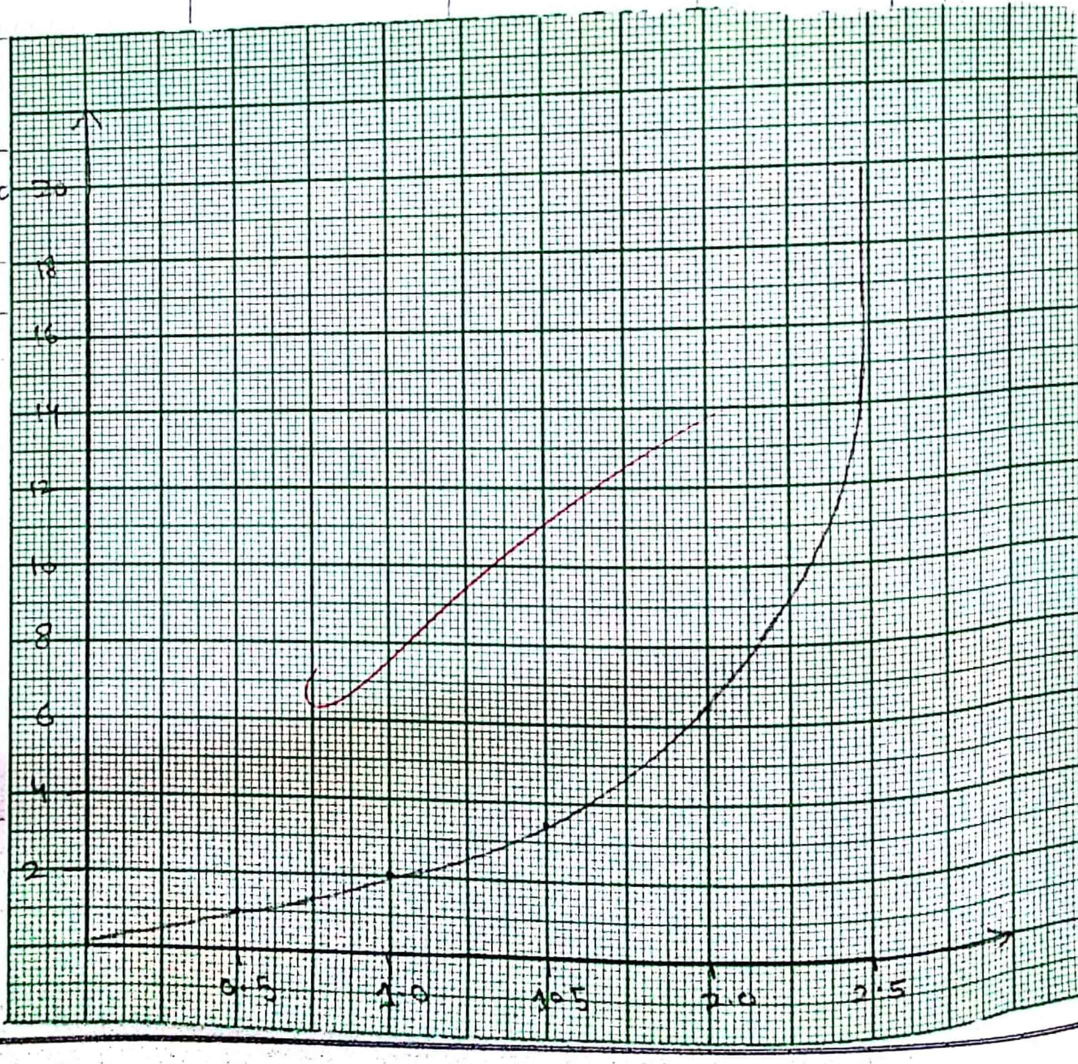
S.No.	Voltmeter reading V_r (volt)		Ammeter reading I_r (μA)	
	n_1	$n_1 \times LC$	n_2	$n_2 \times L.C.$
1	0	0	0	0
2	4	0.2	2	0.4
3	10	0.5	5	1
4	20	1	7	1.4
5	30	1.5	18	3.6
6	40	2	32	6.4
7	50	2.5	96	19.2

Observation

p-n forward Bias

S.No.	Voltmeter reading V_f (Volt)		Ammeter reading I_f (mA)	
	n_1	$n_1 \times L.C.$	n_2	$n_2 \times L.C.$
1	6	0.25	0	0
2	10	0.5	0	0
3	15	0.75	3	0.6
4	20	1	7	1.4
5	25	1.25	12	2.4
6	30	1.5	17	3.4
7	35	1.75	22	4.4
8	40	2	27	5.4

S.No.	Vo
1	
2	
3	
4	
5	
6	
7	



ii) maximum potential or Break-down voltage = 25 V
Range of the milliammeter = 0–100 mA
least count of the milliammeter = 0.2 ~~μA~~ mA.
zero error, if any, in the milliammeter and voltmeter should be adjusted to nil by using a screw driver
Range of microammeter = 0-100 mA
least count of mA scale = 0.2 mA
If adjustment by screw driver is not possible, then record the zero errors also
Range of the Voltmeter = 0-30 V
least count of the Voltmeter = 0.05 V
zero error of the milliammeter = 0 mA
zero error of the voltmeter = 0 V

Precautions and Source of Error

1. Voltmeter and milliammeter of appropriate least counts and ranges should be selected.
2. The variation in V should be done in steps of 0.1 V.
3. In reverse biasing, milliammeter should be replaced by microammeter of range 500 μA and voltmeter should be changed to 15 volt range.

Result

1. The characteristic of p-n junction is forward and reverse biasing are show in the graph.
2. The knee voltage V_k and reverse breakdown voltage and reverse current are ______ V and ______ mA.

Teacher's Signature : ______________

Aim :- To draw the characteristic curve of a zener diode and to determine its reverse break down voltage.

Apparatus

one p-n junction zener diode [IN758A, 0·4W, 10V or IN962B, 1·0W 12V], a power supply with potential divider 0 to 15 V, a resistance of 125 Ω, a micro ammeter of range 0 to 100 μA, a voltmeter 0 to 15 V. with least count 0·1V preferably a digital multimeter, connecting wires etc

Theory

~~As the~~ A zener diode is a heavily doped silicon crystal diode. As the reverse voltage applied to the zener diode increases, it reaches the breakdown voltage at which zener current increases to a large value. In the breakdown region, further increase in the reverse voltage will not increase the voltage across the zener diode, it only increases the current. Thus a constant voltage called zener voltage (V_z) is maintaine across the zener diode when the supply voltage changes. Hence it acts as a voltage regulator. The reverse current that results after the break down, is called zener current (I_z).

$$V = V_0 + i R_P$$

$$i_{maximum} = \frac{P_0}{V_0}$$

$$V = V_0 + \frac{P_0}{V_0} \cdot R_P$$

Observation-

S. No.	Input Voltage (V_I)	Input Current (I_I)
1.	0	0
2	2	0
3	3	0
4	4	0
5	5.1	0.1
6	5.2	0.1
7	5.3	0.1
8	5.5	0.4
9	5.6	9
10	5.7	12.8
11	5.8	15.8
12	5.9	25.2
13	6	31

Zener breakdown voltage = 5.6 V

$$R_P = (V - V_0)\frac{V_0}{P_0}$$

$$= \frac{(V - V_0) V_0}{P_0}$$

the max. specified voltage for a zener diode of Power P_0 be V_0 and be connected across a potential divider arrangement with a max. potential across it V such that $V > V_0$. To save the diode from damage, the applied potential across it must not exceed V_0. Therefore, a protective resistance of value R_P ohm should be connected in series with it such that, the drop of potential across the diode is V_0 and the rest drop across R_P.

Observations

zener diode used : IN 752 A

specification available if any : V_0 = 6.0 V P_0 = 0.4 W

Range of the Voltmeter used = 15 volts

Range of the microammeter = 200 μA μA

least count of the voltmeter = 0.1 V

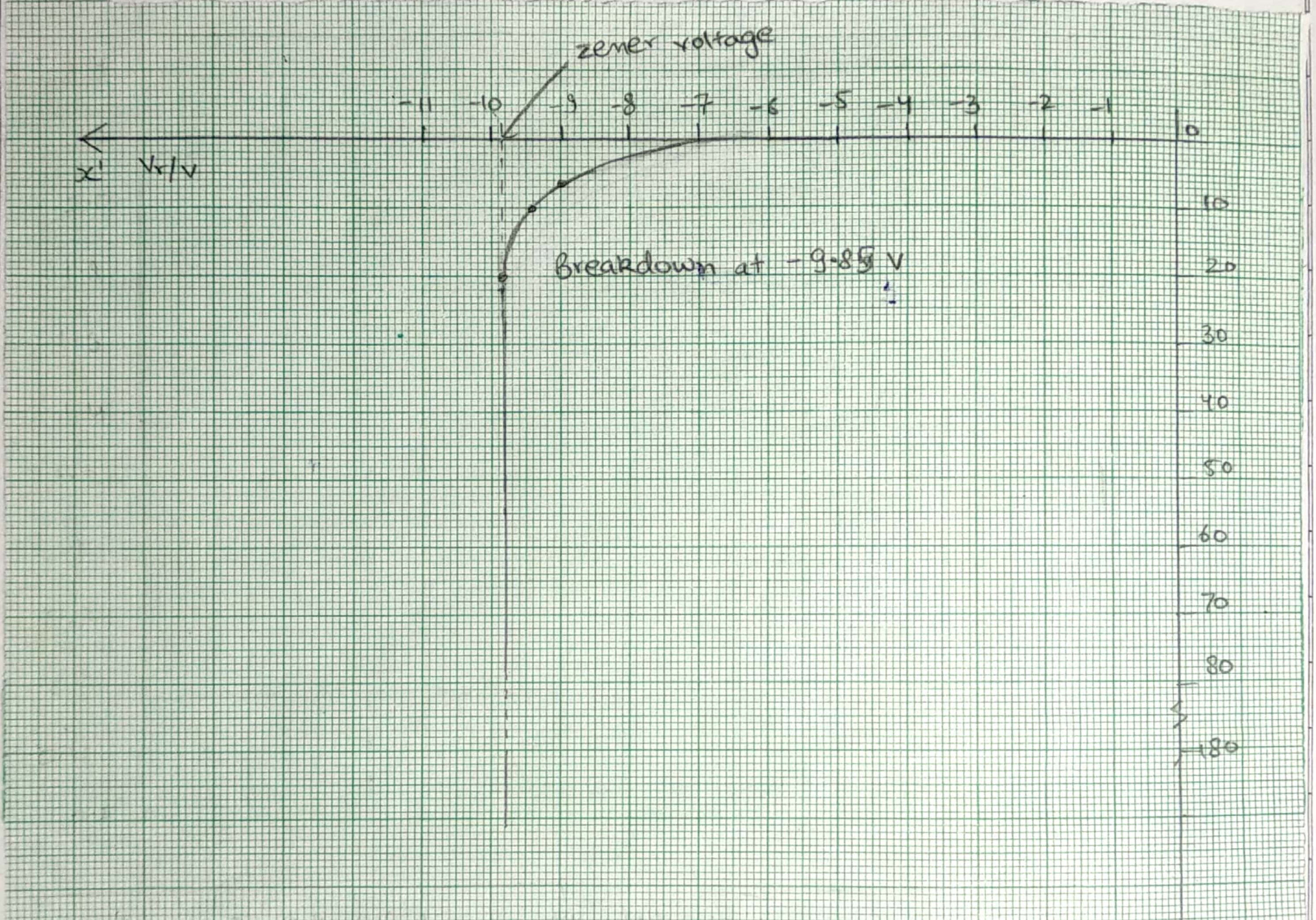
least count of the microammeter = 5 μA

zero error of the microammeter = 0 μA

zero error of the Voltmeter = 0 V

Precautions -

1. Voltmeter and micro ammeter of appropriate least counts and ranges should be selected for use
2. The zener diode p-n junction should be connected



Determination of Vz, Breakdown Voltage

in reverse bias, i.e. p terminal to negative and the terminal marked n to positive of the battery.

3. Try and get from the manual the rough idea about the zener diode's breakdown voltage so that you do not cross or exceed the voltage by more than 5% of the quoted value, otherwise you may go beyond the tolerance limit and damage the diode.

Result

The breakdown voltage determined for,

Diode D_1 (1N758 A) = 5.6 V specified value = 5.6 V

Teacher's Signature :