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Experiment : 1

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

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

Theory:
The refractive index μ of the material of prism is given by,

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

where A is the angle of prism,
D_m is the angle of minimum deviation.

Procedure:

1. Fix a ~~whte~~ white sheet of paper on the drawing board with the help of drawing pins or tape.
2. Draw a straight line XX' parallel to the length of the paper nearly in the middle of paper.
3. Mark points $Q_1, Q_2, Q_3 \ldots$ on the straight line XX' at suitable distances of about 5cm.
4. Draw normals N_1Q_1, N_2Q_2, $N_3Q_3 \ldots$ on points Q_1, Q_2, $Q_3 \ldots$ as shown in diagram.

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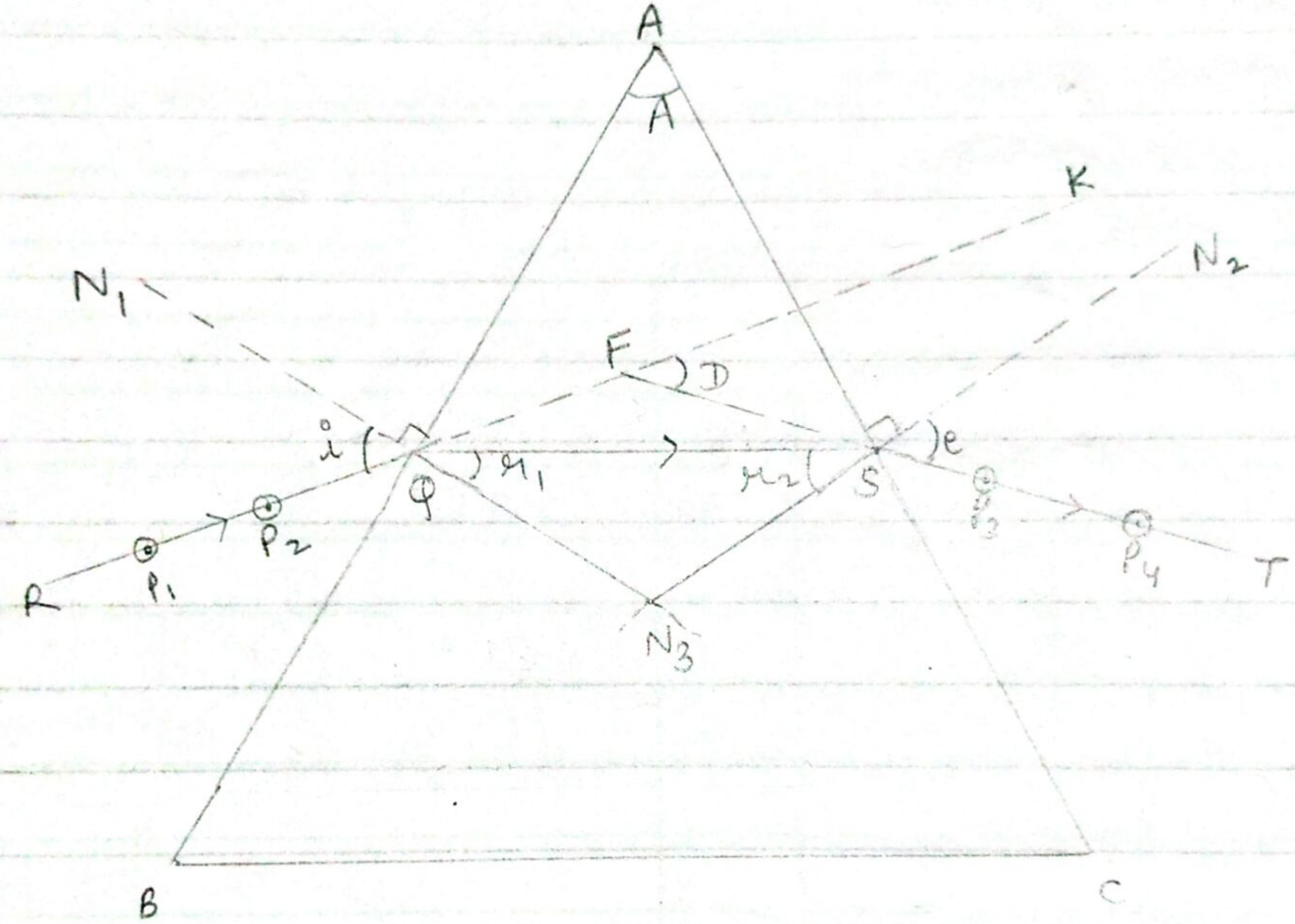
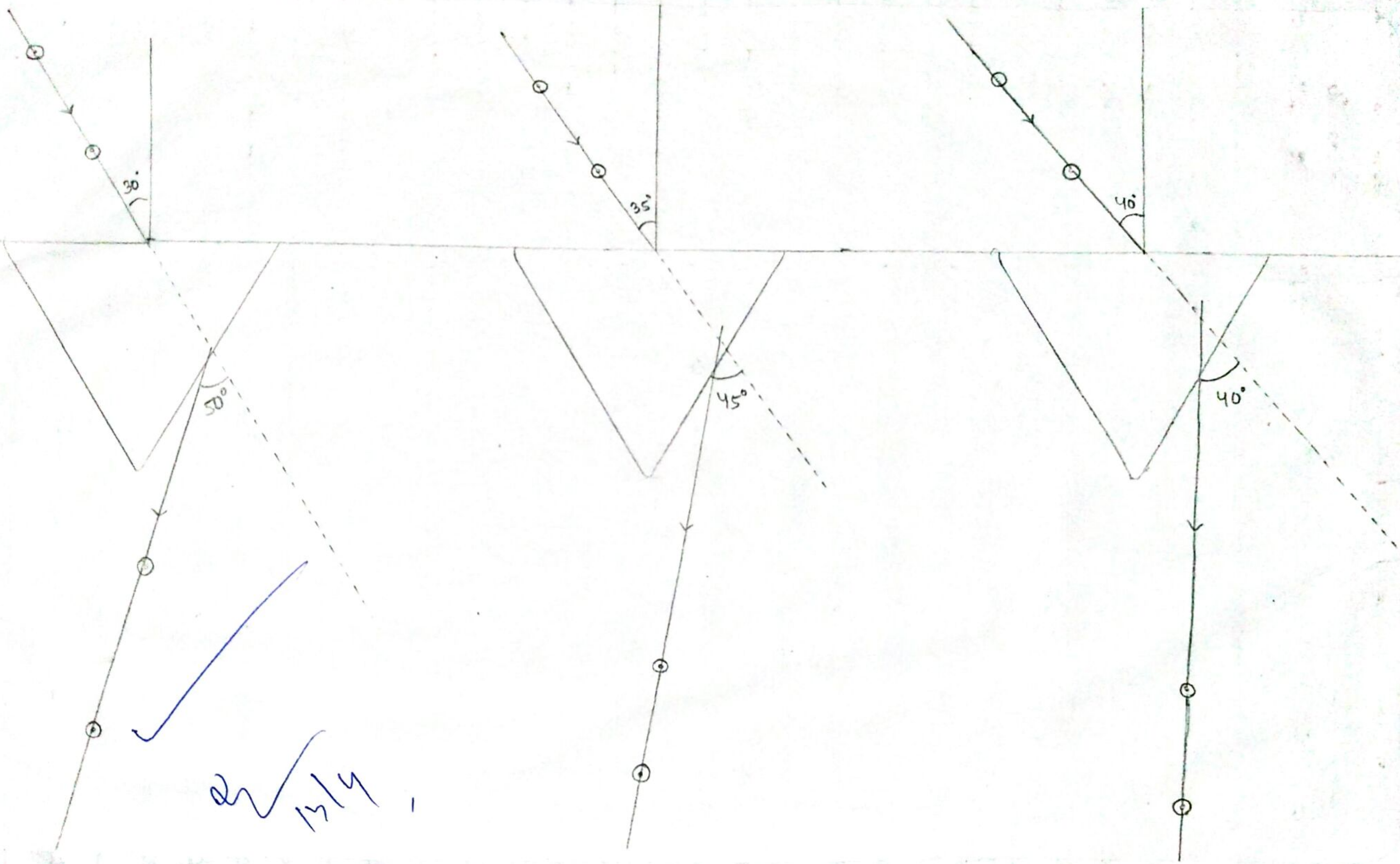


Refraction of light through a prism.

5. Draw straight lines R_1Q_1, R_2Q_2, R_3Q_3... making angles of 30°, 35°, 40°, ... 60° respectively with the normals.
6. Mark one corner of the prism as A and take it as the edge of the prism for all the observations.
7. Put prism with its refracting face AB in the line XX' and point Q_1 in the middle of AB.
8. Mark the boundary of the prism.
9. Fix two or more drawing pins P_1 and P_2 vertically on the line R_1Q_1. The distance between the pins should be 10mm or more.
10. Look at the images of point P_1 and P_2 through face AC.
11. Close your left eye and bring open right eye in line with the two images.
12. Fix two drawing pins P_3 and P_4 vertically, and 10mm apart such that the ~~open~~ right eye sees pins P_4 and P_3 and images of P_2 and P_1 in one straight line.
13. Remove pins P_3 and P_4 and encircle their pricks on the paper.
14. Repeat steps 7 to 13 with points Q_2, Q_3;.. for $i = 40^\circ, \ldots 60^\circ$.

To measure D in different cases.

15. Draw straight lines through points P_4 and P_3 (pin pricks) to obtain emergent rays S_1T_1, S_2T_2, S_3T_3...
16. Produce T_1S_1, T_2S_2, T_3S_3,... inward in the boundary of the prism to meet produced incident rays R_1Q_1, R_2Q_2, R_3Q_3.. at points F_1, F_2, F_3...


30°
35°
40°
50°
45°
40°
13/4

17 Measure angles $K_1F_1S_1$, $K_2S_2F_2$, $K_3S_3F_3$, ... these give angle of deviation D_1, D_2, D_3...
18. Write values of these angles on the paper.

To measure A

19. Measure angle BAC in the boundary of the prism. This gives angle A.
20. Record your observations.

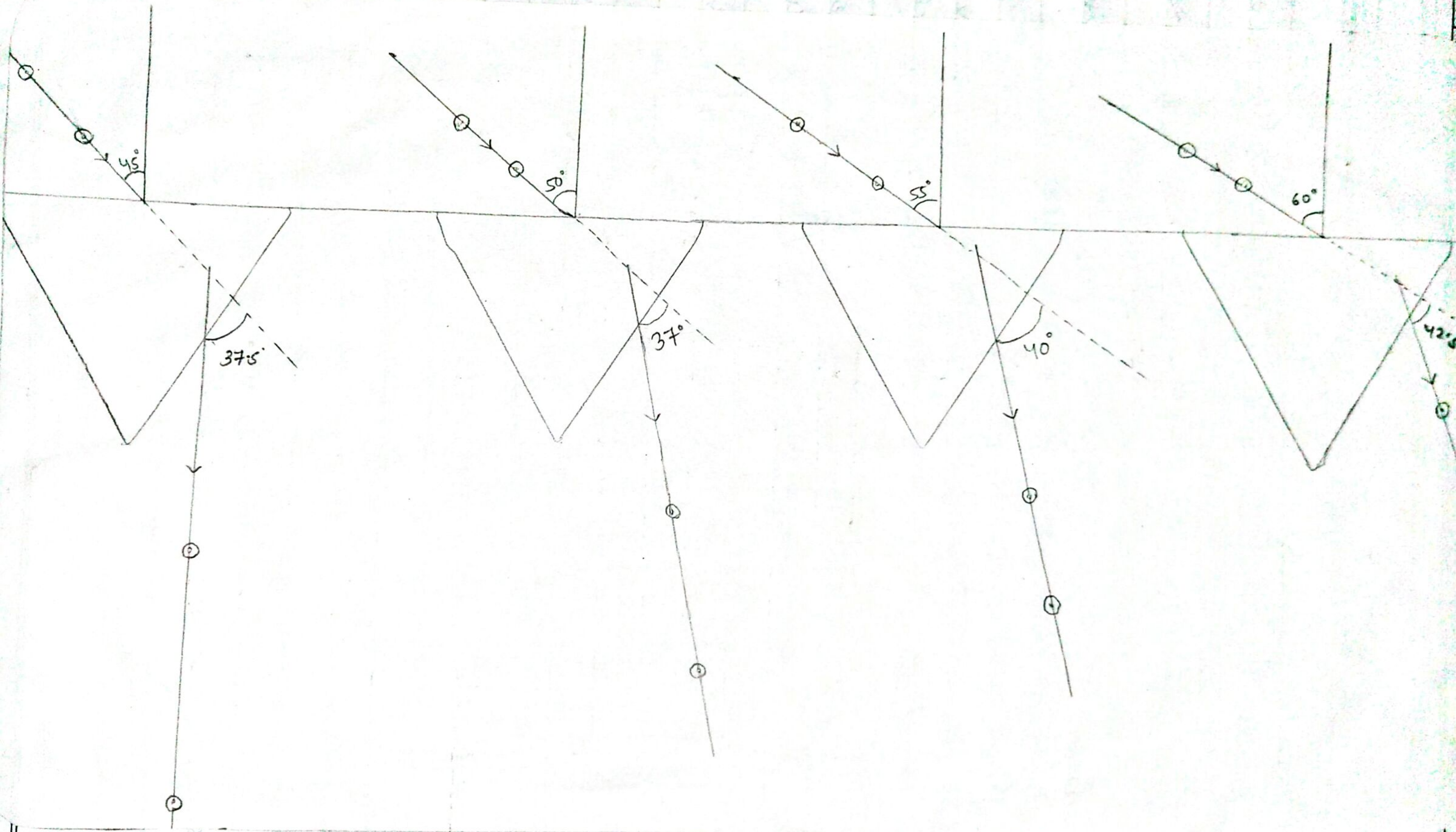
RESULT :

(i) i-D graph indicates that as the angle of incidence i increases, the angle of deviation D first decreases, attains a minimum value (D_m) and then starts increasing for further increase in angle of incidence.

(ii) Angle of minimum deviation, $D_m = 37°$.

Precautions:

1. The pins should be fixed vertical.
2. The distance between the two pins should not be less than 10mm.
3. The same angle of prism should be used for all the observations.


45°
50°
55°
60°
37.5°
37°
40°
42.5

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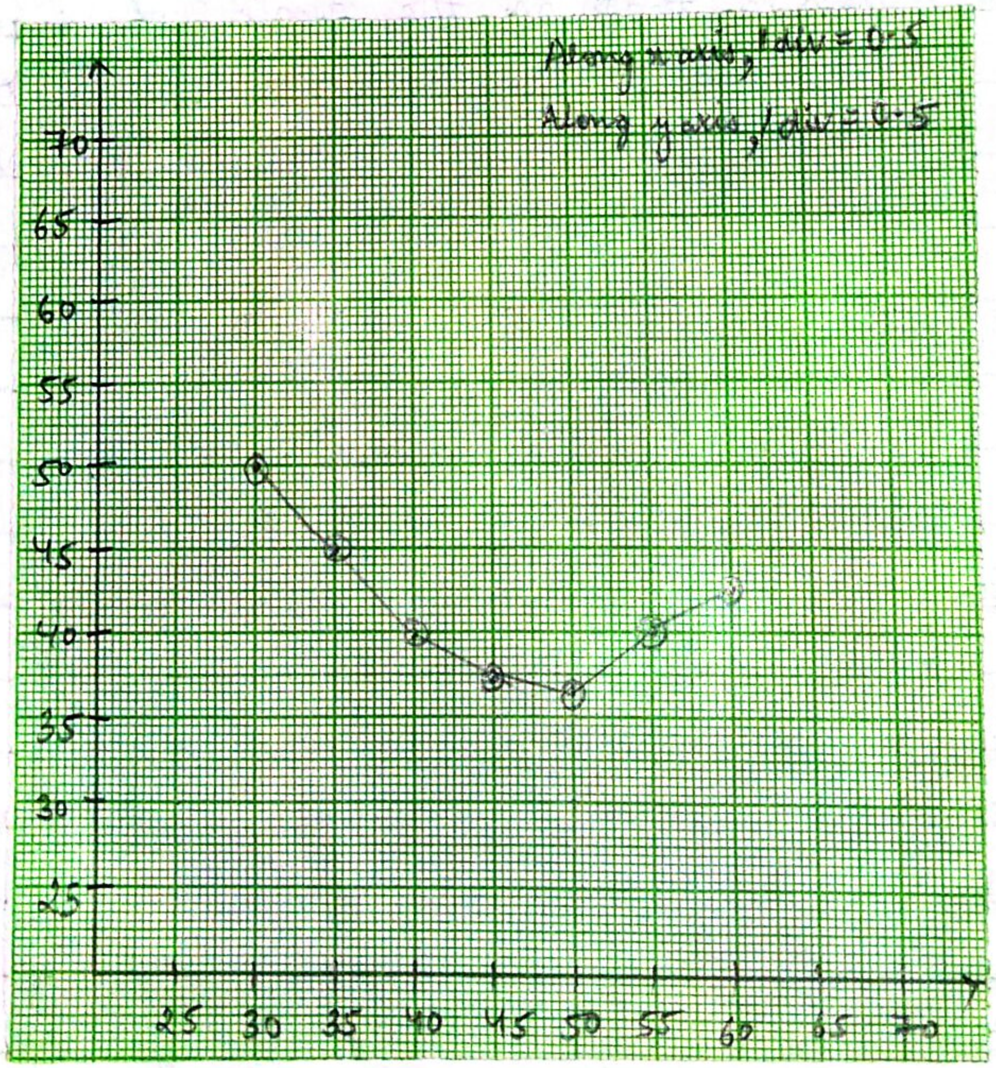
Sources of Error:

1. Pin pricks may be thick.
2. Measurement of angles may be wrong.

Observations:

S.No.	Angle of incidence ($\angle i$)	Angle of deviation ($\angle D$)
1.	30°	50°
2.	35°	45°
3.	40°	40°
4.	45°	37.5°
5.	50°	37°
6.	55°	40°
7.	60°	42.5°



Experiment : 2

Aim: (a) To determine the resistance of a galvanometer by half deflection method.
(b) To find its figure of merit.

Apparatus:
A Weston type galvanometer, a battery or accumulator of 2 volts, 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:
(i) Using half deflection method, the resistance of galvanometer is given by:

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

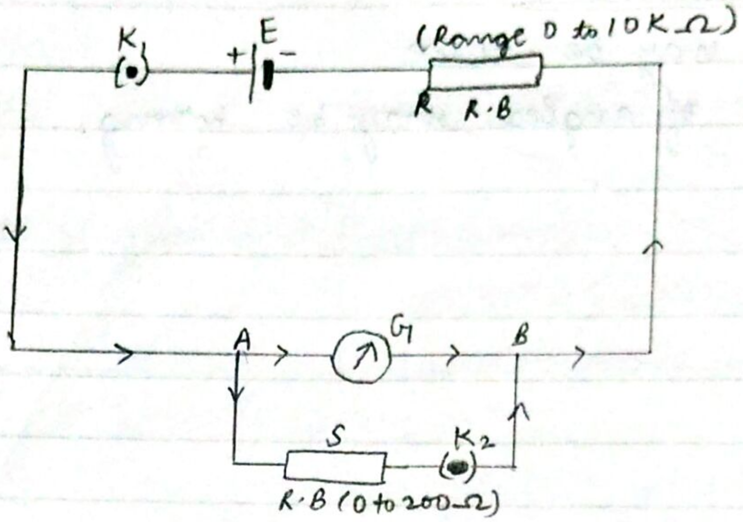
where, R is resistance in series with galvanometer and S is the shunt resistance.

(ii) Figure of merit:

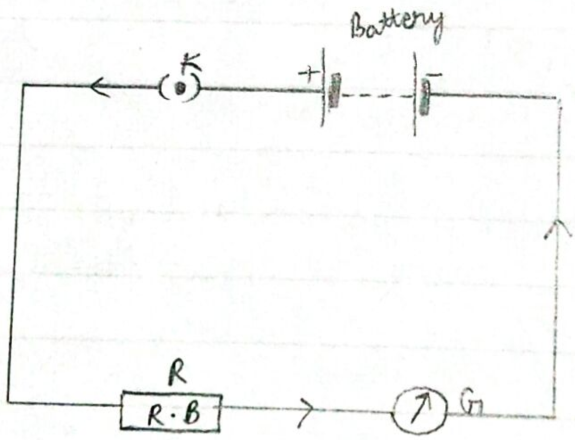
$$k = \left(\frac{E}{R+G}\right)\left(\frac{1}{\theta}\right)$$

where, E is the emf of cell.
θ is the deflection produced in a galvanometer of resistance G when a resistance R is used in series with the circuit.

CIRCUIT DIAGRAM



circuit for determination of resistance of galvanometer by half deflection method.



Determination of figure of merit of the galvanometer

Procedure

(a) G by Half Deflection Method

1: Draw a neat circuit diagram.

2: Produce the necessary apparatus, arrange it properly on the table, Clean the insulation of wires by sand paper and make all corrections as shown in the circuit diagram neatly and tightly.

3. Introduce a high resistance R (about 10,000 ohms) in the resistance box R and then insert the plug in the key K_1. Adjust the value of R to get almost full scale deflection (30 div.) in the galvanometer. Record these values of R and deflection θ.

4. Now close the key K_2 also and adjust the shunt resistance S to get a deflection which is exactly half of θ, i.e., (θ/2). Note this deflection and the value of S.

5. Take four more sets of observations exactly in the same way by changing the value of R suitably so that θ is even number of divisions and record the observations in Table.

(b) Determination of the Figure of Merit

6: Measure the potential drop (E) at the ends of the battery using an accurate voltmeter connecting it in parallel with it. Let it be E volts. Use the readings of R and θ in Table to calculate I_g in the following way:
let θ divisions be the deflection in the galvanometer when a resistance of R ohms is introduced in series

Resistance of the galvanometer by half deflection method

No. of observation	Resistance R (ohm)	Deflection in the galvanometer θ divisions (n)	Required shunt S (ohm)	Half deflection (θ/2) divisions (n/2)	Galvanometer resistance $G = \frac{RS}{R-S}$ (ohm)
1.	3000	30	90	15	92.78
2.	4200	20	70	10	71.18
3.	8700	10	100	5	101.16
4.	7500	12	100	6	101.35
5.	5000	18	80	9	81.3

Mean value of galvanometer resistance, $G = \underline{91.842}\ \Omega$.

No. of observations	Resistance in R.B R (ohm)	Deflection in the galvanometer (θ) (no. of scale divisions) (n)	Figure of merit, $K = \frac{E}{(R+G)\theta}$ (A/div. or ampere/divisions)
1.	10000	10	1.98×10^{-5}
2.	7000	15	1.87×10^{-5}
3.	5000	20	1.96×10^{-5}
4.	3000	30	2.14×10^{-5}
5.	2000	30	3.25×10^{-5}

Mean value of $K = \underline{2.24 \times 10^{-5}}$ A/Div.

with the galvanometer of resistance G when K_2 is not closed. Then the current I_g through the circuit is given by $I_g = \frac{E}{R+G}$ ampere.

Therefore, the current required for the deflection of 1 division in the galvanometer, i.e., the figure of merit k is given as $k = \frac{I_g}{\theta} = \frac{1}{\theta} \cdot \frac{E}{(R+G)}$

7. Repeat the calculations of k for the observations 2, 3, 4 and 5 and enter them in Table. Calculate the mean value of k.

Observations

1) Resistance of the galvanometer (G) by half deflection method = 91.842 ohm.
2) EMF of the cell or battery eliminator, E = 2 volt.

Mean value of $k = 2.24 \times 10^{-5}$ ampere per division.

3) Total number of divisions on either side of the zero of the galvanometer scale, $N_0 = 30$

Result

a) Resistance of galvanometer by half deflection method, G = 91.842 ohm.
b) Figure of merit, $k = 2.24 \times 10^{-5}$ A/division.

Precautions

1: All the connections should be neat and tight. All the plugs in resistance boxes should also be tight.
2: Deflection in the galvanometer should be as large as possible and should be an even number of divisions.
3: Value of R must be very large as ~~as~~ compared to the value of G, otherwise the result will not be satisfactory.

Sources of Error

1: The resistance of the coils in the resistance box used may not exactly be the same as marked.
2: The plugs in the resistance box may be loose which will produce large error in the observations.
3: The emf of the battery may not be constant.

Experiment-3

Aim: To find the resistance of a given wire using a metre bridge.

Apparatus:
A meter bridge, a wire about 1 metre long, a resistance box, a jockey, a key, a galvanometer, a battery eliminator or a lechlanche cell, thick connecting wires, sand paper, screw gauge.

Theory:

a) **Working formula:**
Metre bridge, is a form of wheatstone, under balanced conditions.

$$\frac{P}{Q} = \frac{R}{X}$$

(i) For a metre bridge, the unknown resistance X is given by;

$$X = \frac{(100-l)}{l} \times Q$$

where, X is the resitor of unknown value.
l is the balancing length.
Q is the resistance from resistance box.

(ii) specific resistance (ρ) of the material is given by:

$$\rho = \frac{RA}{l} = \frac{X\pi D^2}{4l}$$

where D is the diameter of given wire.
l is the length of wire.
X is the resistance of given wire.

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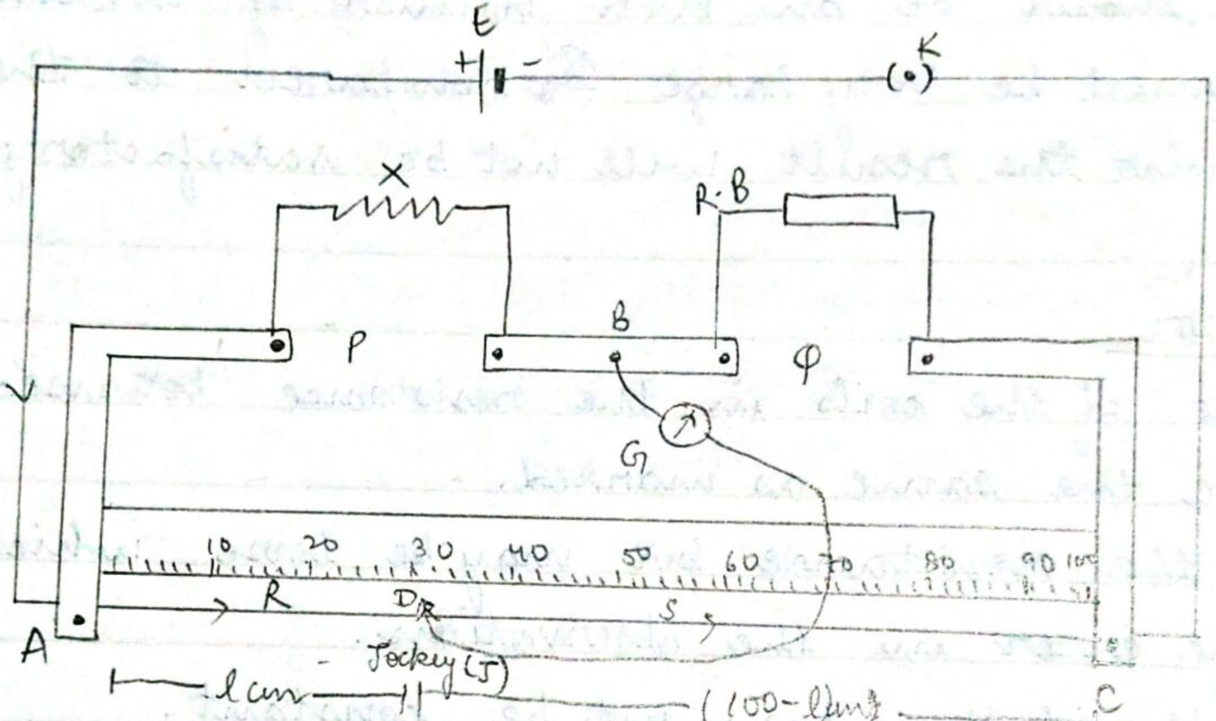
b) Circuit diagram

Measuring unknown resistance of a wire by metre bridge.



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Procedure :

1. ~~Draw~~ Draw the circuit diagram.
2. Arrange the metre bridge and the various components; the coil X, resistance box Q, galvanometer G, battery eliminator or Lechlanche cell E.
3. Clean the insulation at the ends of the connecting wires by rubbing with sand paper.
4. Tighten all the plugs of the resistance box by pressing and turning each plug. Connect the wires tightly, keeping the ~~ag~~ adjust switch of the eliminator at 2V.
5. Ensure that the wire used for connecting the jockey to the galvanometer is sufficiently long.
6. Take out a plug to introduce a suitable resistance say, $Q = 10\,\Omega$ from the resistance box. Use a 2V connector in the eliminator and close the key K to complete the battery circuit.
7. To check the correctness of the circuit, press the jockey near the left end of the wire at point A and note the direction of deflection of the galvanometer needle. Now shift the jockey to the other extreme and note the direction of the deflection again. The directions of deflection should be opposite in the above two cases.
8. Now choose an appropriate value of Q from the resistance box such that there is no deflection in the galvanometer when the jockey is nearly in the middle of the wire (i.e between 30 and 70 cm). This makes the error in measurement of l smaller. Moreover, it ensures better sensitivity of the bridge as the unbalanced current through the galvanometer G per mm change of position of the

Observations and Calculations

least count of metre scale = 1cm
length of wire = 100cm

S.NO	resistance Q (ohm)	Position of Balance point D (cm)	Balancing length AD = l cm	length DC = (100 - l) cm	$X = \left(\frac{100-l}{l}\right) \times Q$ (ohm)
1	2 Ω	2.8	2.8	97.2	$X_1 = 69.4$
2	5 Ω	6.5	6.5	93.5	$X_2 = 71.9$
3	15 Ω	15	15	85	$X_3 = 85$

$$\text{Mean} = \frac{X_1 + X_2 + X_3}{3} = 75.43\,\Omega$$

jockey is more.

Note the position of the null point D, the balancing length AD = l cm and DC = (100 − l) cm.

9. Repeat the above steps four times more by selecting the suitable values of Q for the null point to fall between 30 cm and 70 cm.

10. ~~Measure the diameter of the wire by a screw gauge whose least count and zero error have been determined in advance.~~ M

10. Now cut the resistance wire X at the points where it leaves the binding terminals. Straighten it by stretching and remove any kinks. Measure its length with a metre scale.

Result

Within the experimental error, the unknown value of resistance of the given wire = 75.43 ohms.

Precautions

1. The ends of the connecting wires should be rubbed and cleaned with a sand paper. The connections should be neat, clean & tight.
2. Plugs in the resistance box should be pressed and tightened by screwing them a little in the clockwise direction.
3. The wire should not be ~~passed~~ pressed with the jockey too hard, otherwise the uniformity of the wire will not be maintained.

Sources of Error

1. The wire of the metre bridge may not be of uniform area of cross-section throughout its entire length.

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2. The thick copper strips at the two ends of the wire offer some resistance. They are called end resistances and the errors due to them are called end error and corresponding corrections are called end corrections.

Experiment-4

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

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

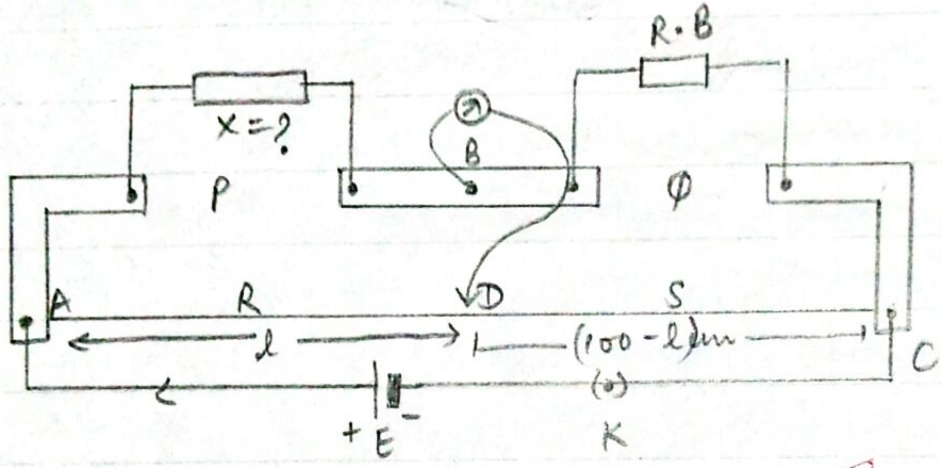
Theory:
(a) Working formula
Laws of combination of resistances ⇒
Series combination.
Two or more resistances R_1, R_2, --- are said to be connected in series if they are connected end to end. The equivalent resistance of this combination, R_s, between the ends A and D is given as:

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

(b) Circuit diagram.

Procedure:
1. Place the resistor X_1 in gap P in the circuit and determine its value
2. Similarly, repeat the observations for resistor X_2 and determine its resistance.
3. Place the series combination of X_1 and X_2 in the left gap P and determine its value X_s.

(a) series combination.



(b) circuit diagram for study of the laws of resistances in series.

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Calculations:

(a) Series resistance by theoretical formula,

$X'_s = X_1 + X_2 = 4$ ohm

(b) Experimental value of the series combination,

$X_s = 4\ \Omega$

Within the experimental error, experimental and theoretical values of the series combination of X_1 and X_2, i.e, X_s and X'_s respectively are almost equal, i.e., $X_s \simeq X'_s$. Hence, the law of combination of resistances in series stands verified.

Result:

1. The values of the individual resistances measured by the metre bridge are:

   $X_1 = 2\ \Omega$ and $X_2 = 2\ \Omega$

2. The equivalent resistance of series combination of X_1 and X_2 is $X_s = 4\ \Omega$.

3. The value of series combination of X_1 and X_2, $X_1 + X_2 = 4\ \Omega$ whereas $X_s \simeq 4\ \Omega$.

   Since X_s is nearly equal to $X_1 + X_2$, the law of series combination of resistances stands verified.

Precautions:

1. The ends of the connecting wires should be rubbed and cleaned with a sand paper. The connection should be neat, clean &

Observation Table for series combination of resistances.

S.NO	Resistance Q(Ω)	length AD = l cm	length DC = (100 - l) cm	unknown resistance $\left(\frac{100-l}{l}\right) \times Q$	Mean R_s (Ω)
1.	2 Ω	76.5 cm	23.5 cm	0.61 Ω	
2.	4 Ω	65 cm	35 cm	2.15 Ω	3.9475
3.	6 Ω	56 cm	44 cm	4.71 Ω	
4.	8 Ω	49 cm	51 cm	8.32 Ω	

$$\text{Mean} = \frac{0.61 + 2.15 + 4.71 + 8.32}{4} = 3.9475\ \Omega$$

$$\simeq 4\ \Omega$$

tight.

2. Plugs in the resistance box should be pressed and tightened by screwing them a little in the clockwise direction.

3. The wire should not be pressed with the jockey too hard, otherwise the uniformity of the wire will not be maintained.

Sources of error:

1. The wire of the metre bridge may not be of uniform area of cross-section throughout its entire length.

2. The thick copper strips at the two ends of the wire offer some resistance. They are called end resistances and the errors due to them are called end error and corresponding corrections are called end corrections.

Experiment-5

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 paper etc.

Theory:

Voltmeter is always connected in parallel with the circuit.

$$R_1 = \frac{V_0}{I_G}\ \Omega$$

where R_1 : total resistance.
I_G : current of galvanometer
V_0 : voltage of galvanometer.

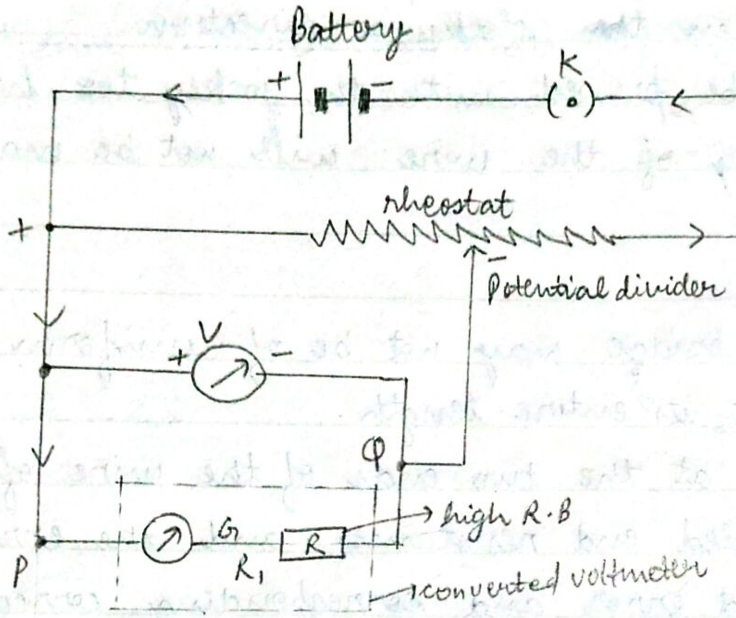
The additional resistance R should be placed in series with galvanometer.

$$R_1 = R + G = \frac{V_0}{I_G}$$

$$R = \left(\frac{V_0}{I_G} - G\right) \text{ ohms.}$$

circuit diagram:

circuit for verification and checking the performance of the converted voltmeter.



Procedure:

1. Record the given values of resistance G of the galvanometer and its figure of merit k.
2. Note the total number of divisions N_0 on either side of the zero of the galvanometer scale.
3. Calculate the value of I_G, the current required to produce full scale deflection in the galvanometer by using the relation $I_G = N_0 k$.
4. Calculate the resistance required to be connected in series with the galvanometer for converting it into a voltmeter reading up to 3 volts by using the relation,

$$R = \frac{V_0}{I_G} - G = \frac{3}{I_G} - G \qquad (\because V_0 = 3 \text{ Volts})$$

5. Connect the resistance box of range (0–10 KΩ) in series with galvanometer for and take out the plugs so as to introduce a resistance R from it, tighten the rest of the plugs. Galvanometer with this resistance in series, is the converted voltmeter.
6. For checking the accuracy of the converted voltmeter, obtain another standard voltmeter. This standard voltmeter (of range 0 to 3V) and the converted voltmeter are connected in parallel with a rheostat. The rheostat is connected to the battery in such a way that it acts as a potential divider. Find the readings of the converted voltmeter after conversion.

Observations:

1. Given resistance of the galvanometer, G = 112.23 ohms.
2. Given value of the figure of merit, $K = 2 \times 1.86 \times 10^{-4}$ amperes per division.

no. of observations	Reading of the converted galvanometer into voltmeter		Standard voltmeter leading (V)	error $V'-V$ (volt)
	in no. of divisions n	in volts $V = K'.n$ (volt)		
1	5	0.5	0.5	0
2	10	1	1	0
3	15	1.5	1.5	0
4	20	2	2	0
5	25	2.5	2.5	0

3. The total no. of divisions on either side of the zero of the galvanometer, $N_0 = \underline{30}$

4. Current required for producing full scale deflection of N_0 divisions, $I_G = K.N_0 = 6.38 \times 10^{-4}$ amperes.

5. Required range of the converted voltmeter, $V_0 = 3$ volts

6. Value of the required series resistance, $R = \frac{V_0}{I_G} - G = 4589.96\ \Omega$

7. Voltage indicated by full scale deflection (N_0) of the converted voltmeter, $V_0 = 3$ volts

8. Least count of the converted voltmeter, $K' = \frac{V_0}{I_G} = 2.186 \times 10^{-4}$ volts/divisions.

__Precautions:__

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.

__Sources of error:__

1. The resistance of the coils in the resistance box used may not exactly be the same as marked.
2. The plugs in the resistance box may be loose which will produce large error in the observations.
3. The emf of the battery may not be constant.

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<u>Result:</u>

For the given galvanometer, $G = \underline{112.23}$ and figure of merit, $k =$

a) Current for full scale deflection, $I_G = \underline{6.38 \times 10^{-4}}$ A

b) The value of high resistance required to be connected in series, R

c) On verification, the mean error = $\underline{0}$. since the error is small, conversion is verified.

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Experiment-6

Aim:

To find refractive index of a liquid by using convex lens and plane mirror.

Apparatus required:

A plane mirror, a convex lens, an optical needle, a clamp stand, a plumb line, a droper and a half meter scale.

Theory:

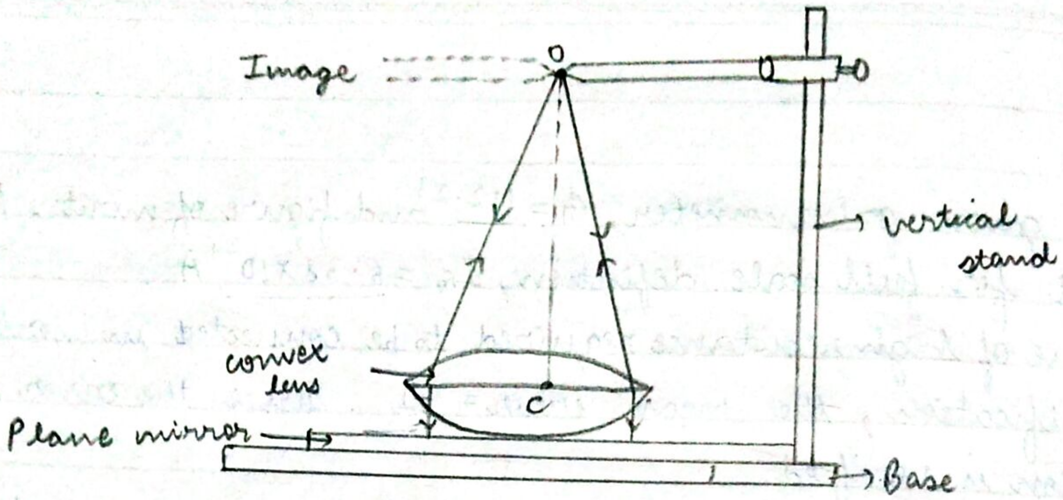
The refractive index of a liquid by using a convex lens and a plane mirror, $n = 2 - \frac{R}{F}$

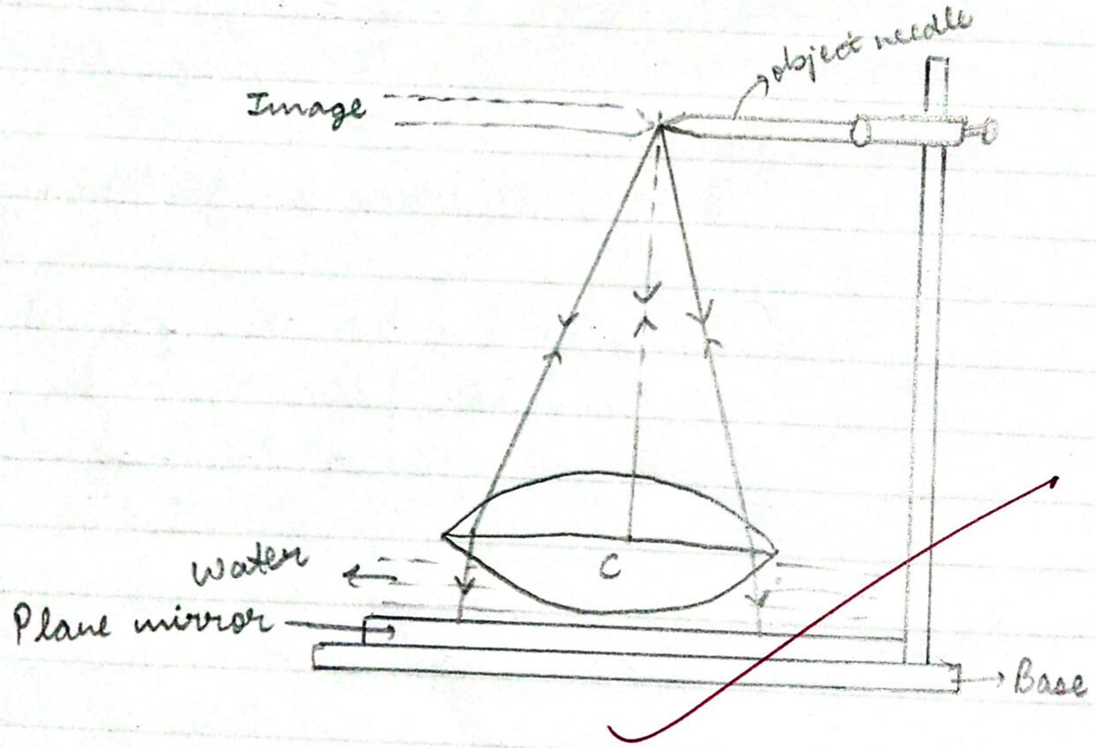
Where, R = focal length of the convex lens $= \overline{OC}$.

F = focal length of compound lens formed by convex lens of glass and plano-concave lens of water = O'C.

Procedure:

1. Place the plane mirror upon the horizontal and flat base of vertical stand. Place the convex lens on the reflecting surface of the plane mirror.
2. Clamp of object needle in the vertical rod of the iron stand. So that its tip is vertically above the optical centre of the convex lens (L).
3. Keeping the eye at least at the centre of distinct vision adjust the position of the object needle and its inverted image is removed tip to tip.





Refractive index of water using a convex lens and plane mirror.

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4. Now with the help of a dropper put a few drops of experimental liquid, i.e, water on plane mirror under the lens. See that no air bubbles are introduced in water in this process. Again ~~ad~~ adjust the position of the object.

5. Repeat the procedure at least three more times and record the observations in the table given below.

Calculations:

Refractive index of water $= 2 - \frac{R}{F} = 2 - \frac{OC}{O'C} = 1.14$

Result:

1. The refractive index of water using a convex lens and a plane mirror, $n = 1.14$

Precautions:

1. Before starting the experiment, clean the convex lens and the plane mirror.
2. Clamp the object needle horizontally so that its tip touches the principal axis normally.
3. The principal axis of the convex lens should be vertical.

Sources of error:

1. The base of the plane mirror may not be horizontal.
2. The liquid may be impure.

Table for the focal length of convex lens, f_g and compound lens, F.

S.NO	Convex lens placed on plane mirror: Distance between object needle and		Focal length of convex lens $f_g = \frac{a+b}{2}$	Convex lens placed on plane mirror with water in btw: Distance btw object needle and		Focal length of the combination $F = \frac{a_1+b_1}{2}$
	lens a cm	Plane mirror b cm		lens a_1 cm	Plane mirror b_1 cm	
1.	32	33	32.5	46	33	39 cm
2.	33.5	33	33.25	41.7	33	37.35 cm
3.	38.4	33	35.7	49.2	33	41.1 cm

Mean f_g : $\boxed{35.81}$ Mean F : $\boxed{39.15}$

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Experiment-7

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

Apparatus:
pn junction diode, battery, rheostat, resistance, milliammeter, microammeter, voltmeter connecting wires.

Theory:
Forward bias diode: A diode is said to be forward bias if p-end of the junction is at higher potential wrt. n-end of the junction.

Reverse bias diode: A diode is said to be reverse bias if p-end of the junction is at lower potential wrt n-end of the junction.

Procedure:

(a) Forward bias:

(i) Make the connections as shown in figure (i).

(ii) Adjust the rheostat of the potential divider arrangement to a minimum value and slowly increase the potential difference across the diode by varying the rheostat.

(iii) Note the reading in the voltmeter and corresponding reading in the ammeter.

(iv) Vary the potential difference so as to have 10 to 12 observations.

(v) Plot the graph taking potential difference on x-axis.

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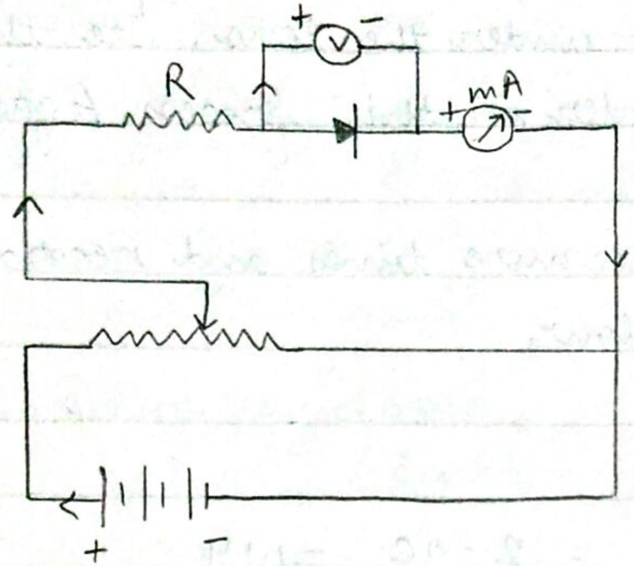
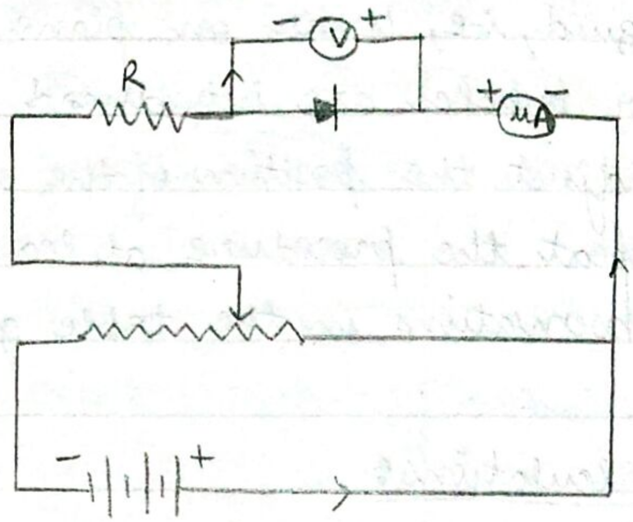


(i) Forward bias diode



(ii) Reverse bias diode

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(b) Reverse bias:

1: Make the connections as shown in fig (ii)

2. Repeat steps (ii), (iii), (iv), (v) of forward bias.

Observations:

(a) Forward bias:

least count of voltmeter = 0.02 V

Zero error of voltmeter = 0 V

least count of ammeter = 0.02 mA

Zero error of ammeter = 0 mA

Range of voltmeter = 0-1 V

Range of ammeter = 0-1 mA

(b) Reverse bias:

least count of voltmeter = 0.02 V

Zero error of voltmeter = 0 V

least count of ammeter = 0.02 ~~m~~ μA

Zero error of ammeter = 0 ~~m~~ μA

Range of voltmeter = 0-100 V

Range of ammeter = 0-1 ~~m~~ μA

Result:

In forward bias of a p-n junction diode with increase in bias voltage, the forward current increases slowly in the beginning and then rapidly.

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Observation Table:

(a) Forward bias

Voltmeter reading V(volt)	Ammeter reading I(mA)
0.4	1
0.5	2
0.56	3
0.6	4
0.64	8
0.68	20
0.72	48

(b) Reverse bias

Voltmeter reading V(volt)	Ammeter reading I(mA)
10	0.12
20	0.24
30	0.38
40	0.54
50	0.76
60	0.98

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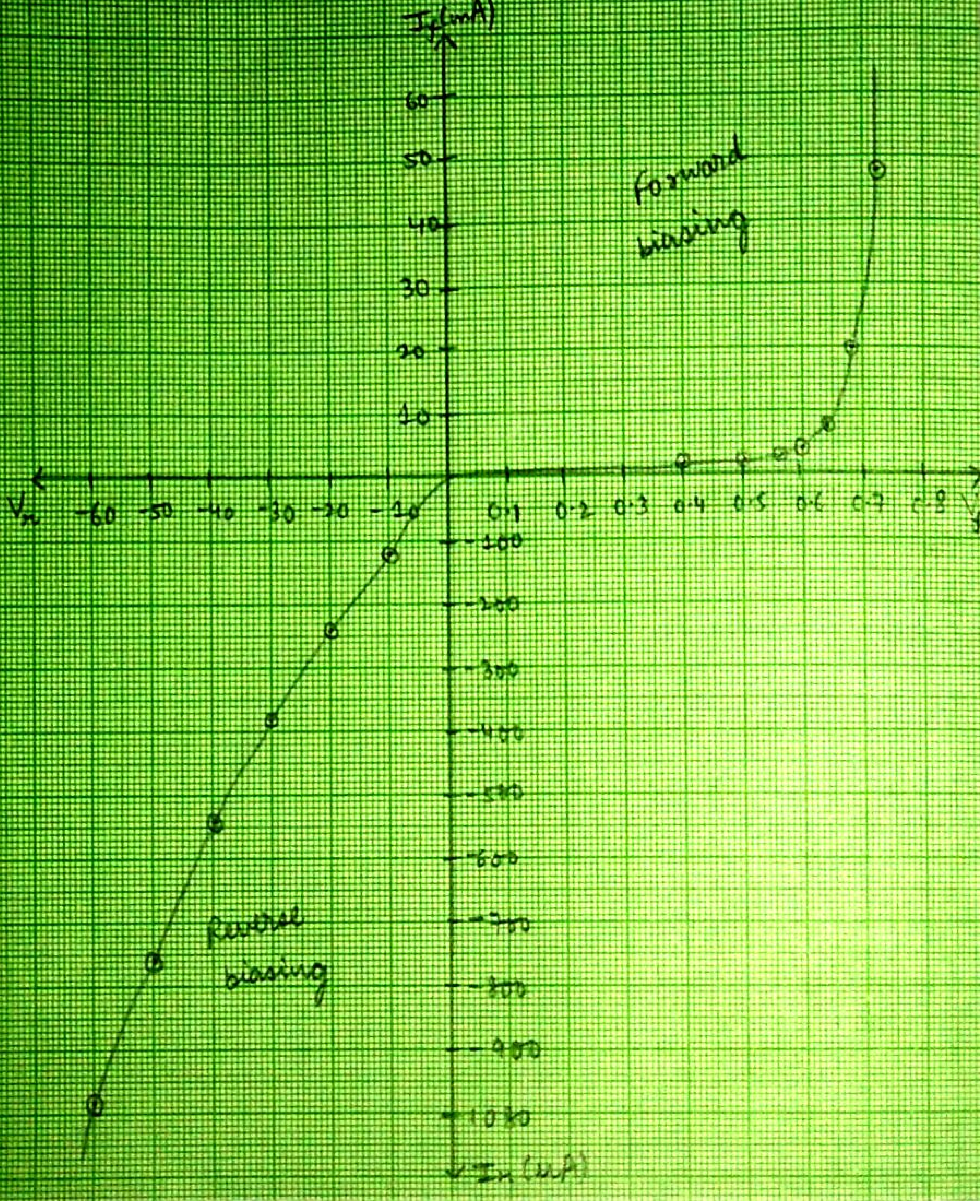
In the reverse bias of a p-n junction, when reverse bias voltage increases, initially there is a very small reverse current flow, which remains almost constant with bias. (But if reverse bias voltage increases then reverse current also increases to a large value).

Precautions:

1: All connections should be tight and neat.
2: The variation in V should be done in steps of 0.1 V.
3. Voltmeter and milliammeter of appropriate least counts and ranges should be selected.

Sources for error:

1. The diode is not suitably biased.
2. Zero error is not accurately estimated.
3. Current is fixed through the diode for long duration.



I_f (mA)
60
50
40
30
20
10
Forward biasing
V_r
-60 -50 -40 -30 -20 -10
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1000
Reverse biasing
I_r (uA)

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Experiment - 8

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:

Suppose a convex lens L is interposed between a convex mirror M and an object needle O as shown in figure. When the relative positions of M, L and O are adjusted in such a way that there is no parallax between object needle O and its image I.

Now, without disturbing the positions of the object O and the lens L the convex mirror is removed, and another needle is placed in the position of the image I' of the object O, formed by the lens L.

Measure MI'.

$$\text{Now, } f = \frac{r}{2} = \frac{MI'}{2}$$

Procedure:

1: Mount the convex mirror M, a convex lens L and the object needle O on an optical bench as shown. Look for the inverted image of O through the system of the lens L and the mirror M by adjusting the position of O or L wrt that of the mirror. If the inverted image is not obtained, a convex lens of larger focal length should be used.

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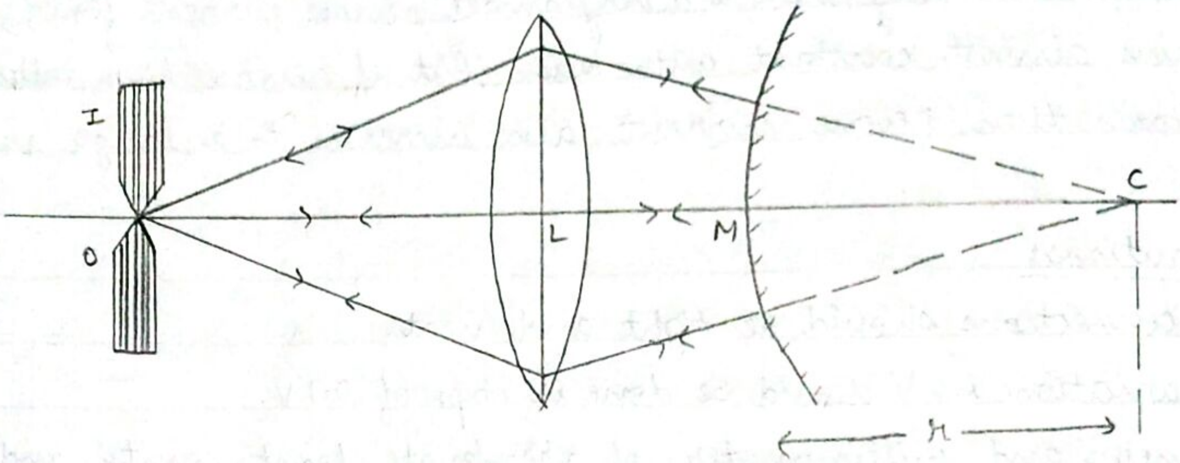
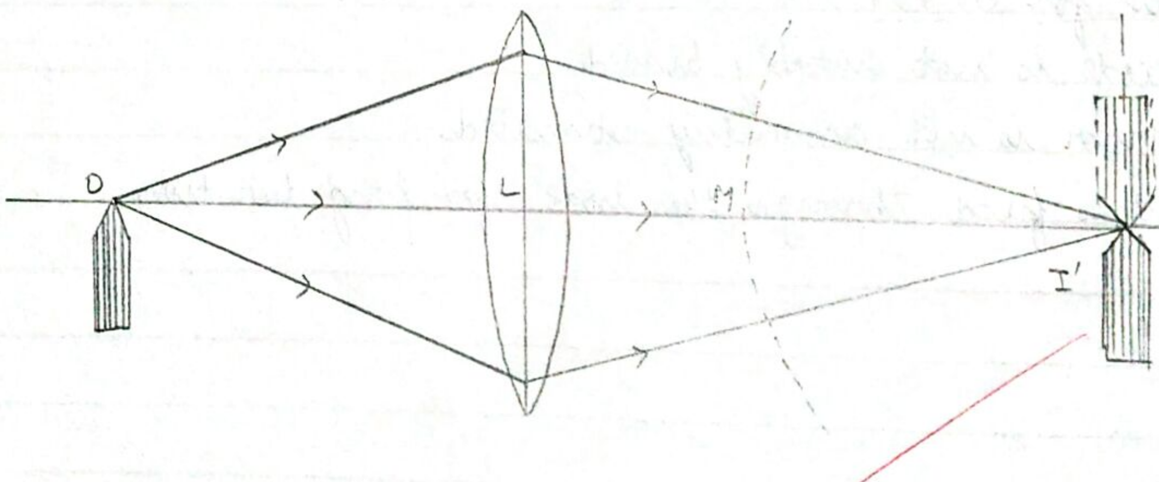
(a)



(b)



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2. Remove the parallax between the object needle O and its inverted image and note the positions of O, L and M on the bench side.
3. Remove the mirror M and do not disturb the lens L and O at all. Take another needle I' and place it on the other side of the lens.
Adjust the position of the needle so that there is no parallax between the needle I' and the inverted image of object needle O formed by the lens. Note this position of the needle I' on the optical bench.
4. Take five sets of observations for different positions of O and L.
5. Determine the index correction between the mirror M and the image needle I'.

Observations and Calculations:

Index correction

length of the knitting needle, $y = \underline{17.5}$ cm

Observed distance with the needle between M and I, $x = \underline{17.5}$ cm.

$\therefore$ Index correction between M and $I' = (y-x) = \underline{0}$ cm.

corrected distance, $MI' = \underline{6.09}$ cm

$\therefore f = \frac{\text{corrected } MI'}{2} = \underline{3.045}$ cm.

Result:

Focal length of the given convex mirror $= \underline{3.04}$ cm Low

$= \underline{0.03}$ m

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Observation Table:

S.NO.	Position of the object needle O(cm)	Position of the lens L(cm)	Position of the mirror M (cm)	Position of the image needle I' (cm)	observed distance MI' (cm) (I' - m)
1	15	60	70	78.6 cm	8.6 cm
2	13	60	73	78.5 cm	5.5 cm
3	12	60	74	78 cm	4.0 cm

$$\text{mean } MI' = \frac{8.6+5.5+4}{3} = 6.09 \text{ cm}$$

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Precautions:

1. The line joining the pole of the mirror, the centre of the lens L, and the tip of the needle, should be parallel to the length of the optical bench.
2. The auxiliary lens L must have sufficiently large focal length.
3. In the second part of the experiment, i.e., after removing the mirror M, the positions of L and O should not be disturbed at all.

Sources of error:

1. Focal length of lens may not be small.
2. The uprights may not be vertical.
3. Parallax removal may not be perfect.