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EXPERIMENT- 1

AIM : To determine the resistance per cm of a given wire by plotting a graph of potential difference versus current and hence to determine its resistivity.

THEORY:

According to Ohm's law, "If physical conditions of a conductor such as temperature, pressure etc. remains constant, then electric current (I) flowing through the conductor is directly proportional to the potential difference (v) applied across the ends of the conductor,

i.e. $I \propto V \implies V \propto I$ OR $V = IR$

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

R = constant of proportionality.

called RESISTANCE OF THE CONDUCTOR.

R depends upon the material, temperature and dimensions of the conductor. To establish current voltage relationship, it is to be shown that ratio V/I remains constant for a given resistance. For a wire of uniform cross section, the resistance depends on the length 'l' and area of cross section "A"

$$R = \rho \frac{L}{A}$$
ρ = resistance (specific) or resistivity of the material of wire.

CIRCUIT DIAGRAM

Battery

K

Rheostat

A

R

unknown resistance wire

V

+ −

I
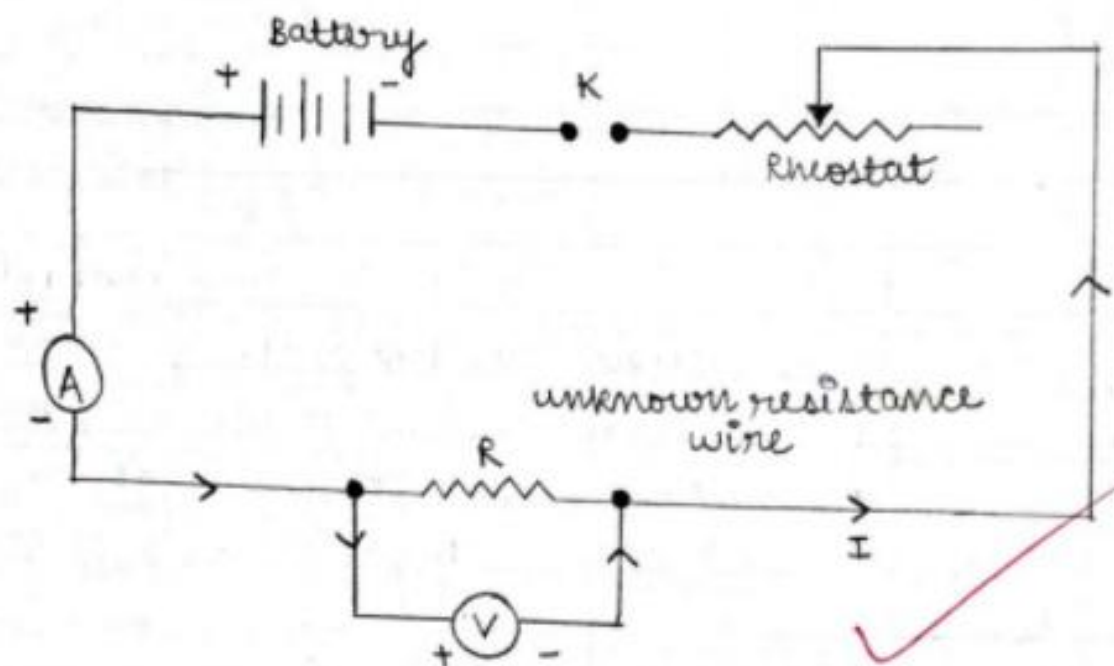
$$P = \frac{RA}{l} \implies P = \frac{\pi r^2 R}{l}$$

For a graph between potential difference (V) and current (I), it must be a straight line.

MATERIALS REQUIRED- a resistance wire, voltmeter and ammeter of appropriate range, battery, rheostat, metri scale, one way key, connecting wires, piece of sand paper, screw guage.

OBSERVATIONS-

1. Range → Ammeter → 0 - 500mA
   voltmeter → 0-5V

2. least count → Ammeter → 10mA   voltmeter → 0.1V.

3. Zero Error → Ammeter → 0A   voltmeter → 0V.

4. Zero correction → Ammeter → 0A   voltmeter → 0V.

RESULT - 1. Ohm's law is verified as the I vs V graph is a straight line.

2. The resistance of the given wire = 0.28 Ω

3. The resistance per cm of given wire = 0.695 Ω m⁻¹.

PRECAUTIONS - 1. All the electrical connections must be neat, clean, tight.

2. voltmeter and ammeter should be of proper range

3. the key should be inserted only while taking readings

SOURCES OF ERROR - ① the instrument screws may be loose.

② Thick connecting wires may not be available.

③ Rheostat may have high resistant.

OBSERVATION TABLE

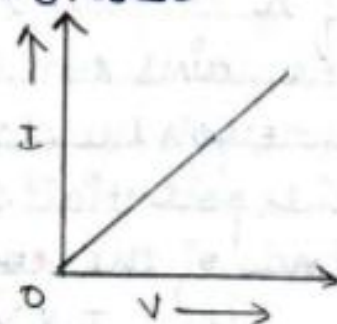| Ammeter		Voltmeter		Ratio
OBSERVED	CORRECTED	OBSERVED	CONNECTED	$(R = V/I \ ohm)$
0.3	0.3	0.1	0.1	0.33
0.7	0.7	0.2	0.2	0.28
1.1	1.1	0.3	0.3	0.27
1.5	1.5	0.4	0.4	0.26
1.9	1.9	0.5	0.5	0.26

CALCULATIONS :

Mean value of V/I from observations, $R = 0.28 \, \Omega$

Length of resistance wire $= 40.2 \, cm$

Value of slope of V−I graph $= 0.27 \, \Omega$

Resistance per unit length $= 0.675 \, \Omega m^{-1}$
   (R/L)

In $\triangle ABC$, $\tan\theta = \dfrac{AB}{CB} = \dfrac{\Delta I}{\Delta V}$

$\cot\theta = \dfrac{\Delta V}{\Delta I} = R$

$\therefore R = \cot\theta$

LEARNING OUTCOMES-

■ Students learn ohm's law.

■ Students know the relation b/w voltage, current and resistance.

■ Students learn how to find out the resistivity of the material of a given wire.

EXPERIMENT -2

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

MATERIALS REQUIRED - A metre bridge, Battery eliminator / Leclanche cell, Galvanometer, Resistance box, jockey, one way key, A resistance wire, screw guage, metre scale, connecting wires.

THEORY- _Wheatstone principle_ (Fig. 1)
The metre bridge operates under wheatstone's principle. Here, four resistors P, Q, R, S are connected to form the network ABCD. The terminals A and C are connected to a galvanometer through keys K_1 and K_2 respectively. In the balancing conditions, there's no deflection in the galvanometer then, $\frac{P}{Q} = \frac{R}{S}$

Metre Bridge Apparatus (Fig. 2)
A metre bridge or slide wire bridge is the practical form of wheatstone bridge. If R-Resistance and there's no deflection in galvanometer then-
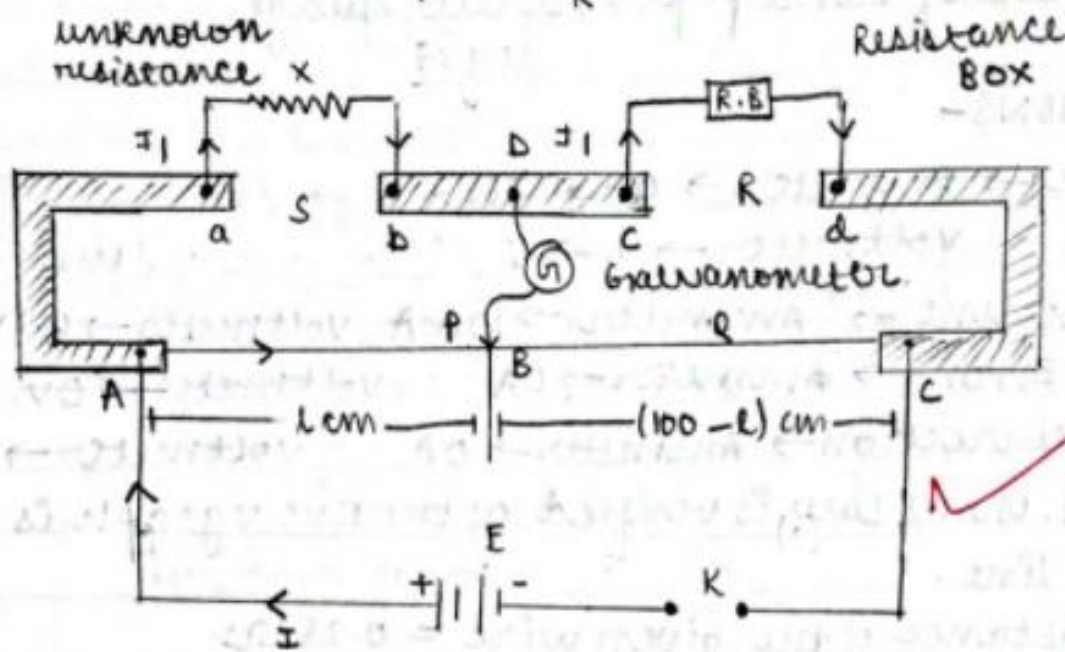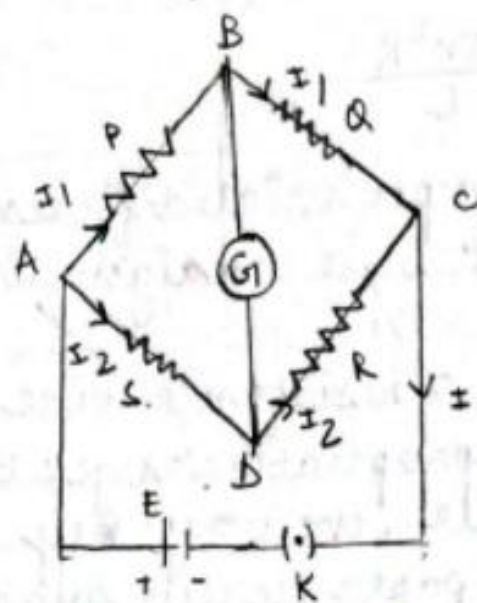length of wire AB = l, length of wire BC = $(100-l)$
Resistance of wire AB = $P = \frac{PL}{A}$
Resistance of wire BC = $Q = \frac{P(100-l)}{A}$ where A= area of cross section of wire
and P = resistivity of the material of the wire.

Fig 1

unknown resistance x

Resistance Box

R.B

S   b   D I_1 R

a   C   d

I_1 I_1

G Galvanometer

P   Q

A   B   C

L cm $(100-L)$ cm

E

+ | | | −   K

Leclanche cell / Battery eliminator.

Fig 2.

OBSERVATION TABLE

Resistance from BOX (R ohm)	length AB = L cm	length BC = (100−L) cm	unknown Resistance x = R(100−L)/L ohm
0.5	58.3	41.7	0.35
0.7	60.7	39.3	0.45
1	61.9	38.1	0.65
1.5	61.1	38.9	0.95
			mean = 0.59

Radius of resistance wire

main scale reading (mm)	Circular scale Reading	Total reading diameter (mm)	mean D	Mean radius
0	43	0.43	6.42	0.21

LEARNING OUTCOME −

① students understand wheatstone's bridge and it's principle.

② students verify wheatstone's principle.

③ students correlate the principle of wheatstone's bridge with metre bridge experiment.

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

If the resistance/unit length = 6 then

$$\underline{\text{Resistance of wire } AB} = \frac{P}{Q} = \frac{l \cdot 6}{(100-l)\,6}$$
$$\text{Resistance of wire } BC$$

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

$$\frac{P}{Q} = \frac{R}{S} \implies S = \frac{QR}{P} \implies S = \frac{(100-l)\,R}{l}$$

$$\rho = \frac{SA}{L} = \frac{S\pi r^2}{L} \qquad \text{If } D = 2r, \quad \rho = \frac{S\pi D^2}{4L}$$

OBSERVATION – (i) length of wire, $L = 66$ cm.

(ii) Pitch of screw guage = 0.01

Total no. of division on the circular scale = LC of screw guage = Pitch / no of circular scale.

RESULT – value of resistance $(x) = 0.5\,\Omega$

specific resistance of material of wire = $0.104 \times 10^{-3}\,\Omega m$.

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

PRECAUTIONS : 1. The connections should be neat, clean, tight

2. The movement of jockey should be gentle, it shouldn't be rubbed.

3. The key should be inserted only when the obs. are to be made.

SOURCE OF ERROR

1) The screws of the instrument might be loose.

2) The wire might be of non-uniform diameter.

3) There might be backlash error in the screw guage.

EXPERIMENT-3

AIM: To verify the law of series combination of resistances using a metre bridge.

MATERIALS REQUIRED: metre bridge, a leclanche cell / battery eliminator, Galvanometer, Resistance box (0.1 to 10 Ω), jockey, one way key, two resistance wires, screw guage, metre scale, sett square, wires.

THEORY: Metre Bridge

The metre bridge, consists of a one metre long wire of uniform cross-sectional area, fixed on a wooden block. A scale is attached to the block. Two gaps are formed on it by using a thick metal strips in order to make the wheatstone's bridge.

1. If two or more than two resistors say R_1, R_2, R_3 -- are attached in series, then their resultant resistance R_S is equal to the sum of individual resistances connected in series i.e. $R_S = R_1 + R_2 + R_3 + - - ...$

2. The value of unknown resistance S can be determined using metre bridge by the formula

$$S = \left(\frac{100 - l}{l}\right) R.$$

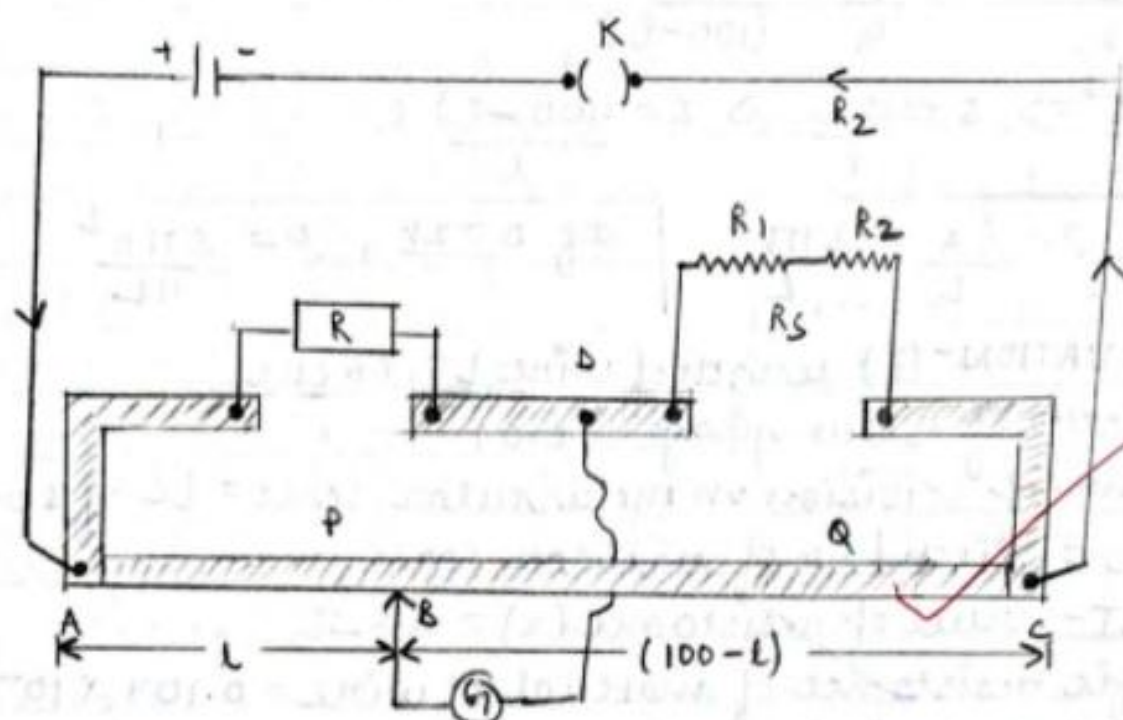where R = resistance intro. in known arm by the resistance box and l is the length of metre bridge wire from zero end to balance pt. for which galvanometer shows no deflection.

Teacher's Signature : _____

Fig 1

Resistances in series.

Circuit diagram for series combination of resistors
(Fig 2)

OBSERVATION TABLE

Resistance coil	Resistance from box	length AD = l cm	length DC = $(100-l)$ cm	$r = \frac{(100-l)R}{l}$	Mean R.
r₁ only	0.5	24	76	1.583	
	1	38	62	1.631	1.616
	2	55	45	1.636	
r₂ only	0.5	33	67	1.015	
	1	50	50	1	1.015
	2	66	34	1.030	
r₁ and r₂ in series	0.5	16	84	2.625	
	1	28	72	2.571	2.615
	2	43	57	2.651	

calculation

$R_1 + R_2 = 1.616 + 1.015 = 2.631 \, \Omega$

$R_s = 2.615 \, \Omega$

$\therefore$ experimental error $= \dfrac{2.615 - 2.631}{2.615} \times 100 = 0.6 \%$

RESULT

within limits of experimental error, experimental and theoretical values of resistance of series combination of resistance coils R_s are same. Hence, law of resistors in series is verified.

PRECAUTIONS

1. The connections should be neat, clean & tight.
2. Key should be inserted only while taking observations to avoid heating of resistance.
3. Move jockey gently over the metre bridge wire.

SOURCES OF ERROR

1. Instrument screw may be loose.
2. Unavailability of thick connecting wire.
3. The key in the resistance box may be closed.

LEARNING OUTCOMES-

• when 2 resistors are connected in series, its eq. resistance increases.
• Law of combination of resistors connected in series.
• Law of combination of resistors connected in parallel.

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EXPERIMENT-4

AIM: To compare the emfs of 2 given primary cell using a potentiometer.

MATERIALS REQUIRED - Potentiometer, Daniel cell, lelanche cell / Battery eliminator, jockey, Resistance box, Galvanometer, one way key, two way key, Rheostat, Ammeter, connecting wires.

THEORY

when a constant current flows through a wire of uniform area of cross section and composition, then the potential drop across any length of the wire is directly proportional to that length le.

$$V \propto L$$
$$V = KL$$

where K is the potential gradient in the wire. If l_1 and l_2 are the balancing lengths on the potentiometer wire corresponding to two primary cells of emfs E_1 and E_2 then

$$E_1 = KL_1$$
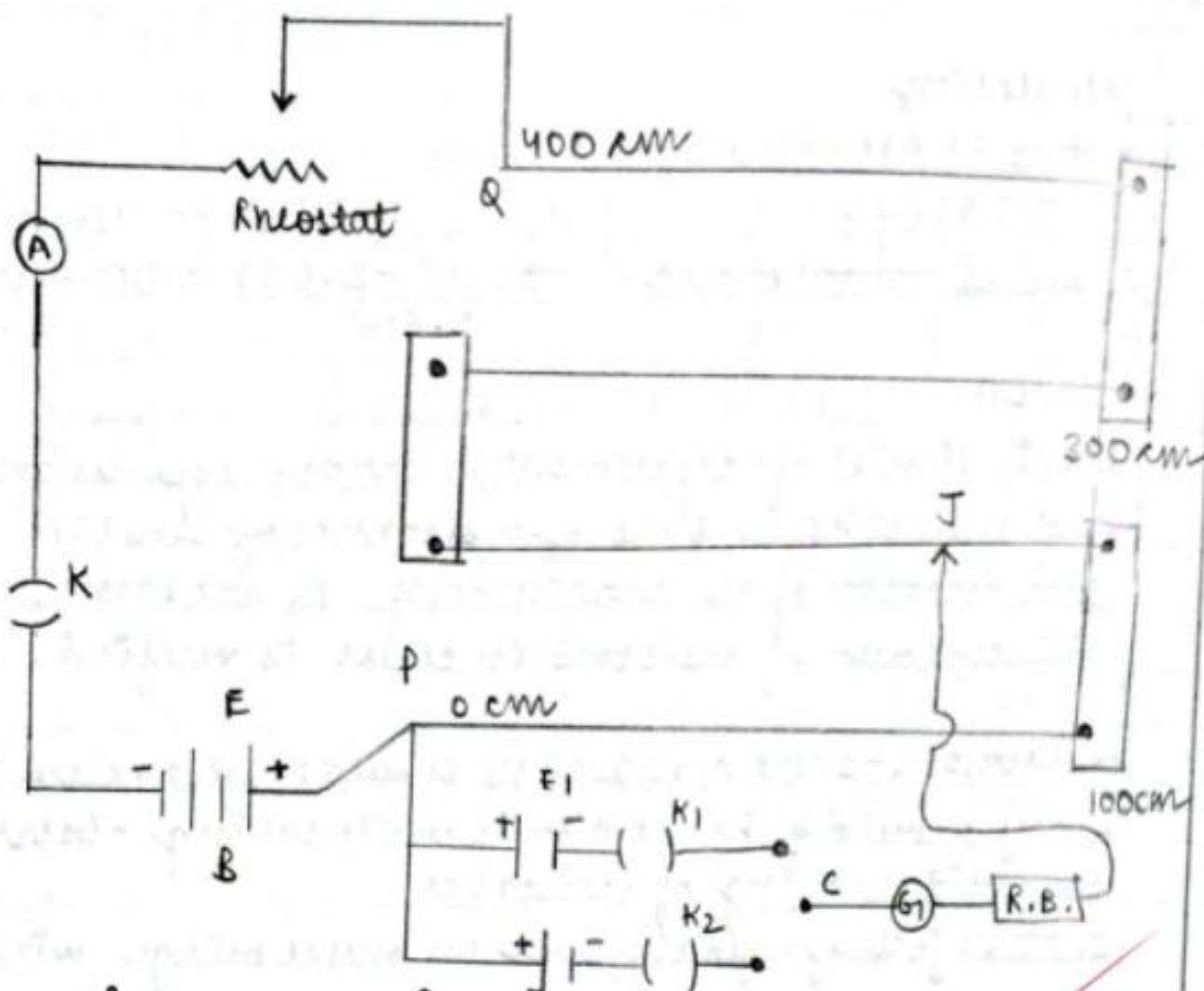$$E_2 = Kl_2$$

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

Fig 1 comparision of emf of 2 cells

OBSERVATION TABLE

S.NO.	LECLANCHE CELL l_1 for cell E_1 (cm)	DANIEL CELL l_2 for cell E_2 (cm)	$\dfrac{E_1}{E_2} = \dfrac{L_1}{L_2}$
1.	327	376	0.86
2.	323.5	371	0.87
3.	321.5	369	0.87
4.	312.5	352.5	0.88

calculations

$$\text{mean } \frac{E_1}{E_2} = \frac{0.86 + 0.87 + 0.87 + 0.88}{4} = 0.87$$

Result

The ratio of emf $\Rightarrow \dfrac{E_1}{E_2} \sim 0.87$

PRECAUTION

1. All positive terminals should be connected to zero and A of potentiometer wire.
2. The emfs of the battery should be greater than emfs of the other cells.
3. Some high resistance plugs should always be taken out from resistant the jockey is moved along the wire

SOURCES OF ERROR

1. The potentiometer wire may not be of uniform area of cross-section
2. The emf of battery may not be constant.
3. The end resistance may not be zero.

LEARNING OUTCOMES

- understanding of the potentiometer apparatus, its parts and how to use it.
- learning of concept of electromotive force in cells.
- Ability to construct circuit based on circuit diagram.

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<div align="center">EXPERIMENT-5</div>

AIM- To determine the internal resistance of given primary cell using potentiometer.

MATERIALS REQUIRED: Potentiometer, Battery eliminator, one way keys, Rheostat, galvanometer, high resistance box, Lechanche cell, Jockey, ammeter, connecting wires.

THEORY-

Potentiometer works on the principle that when a constant current flows through a wire of uniform cross-sectional area, potential difference b/w it's two points is directly proportional to the length of the wire b/w 2 points.

If o cell of EMF, E, internal resistance r, connected to an external resistance 'R', then the current has total resistance (R+r). The current 'I' in the circuit is-
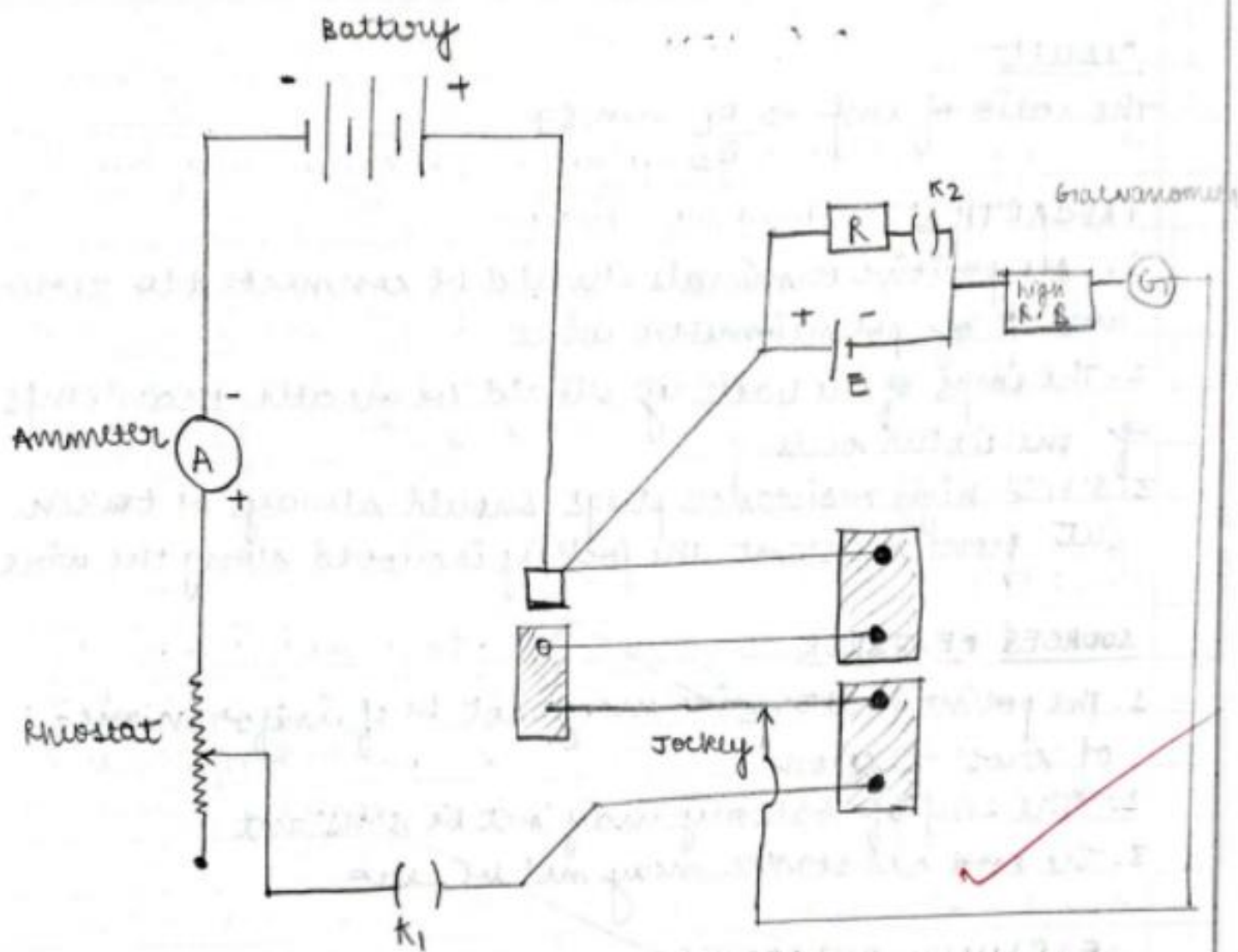
$$I = \frac{E}{R+r}$$

$$E = IR + Ir$$
$$\Rightarrow E = V + Ir$$
$$\Rightarrow V = E - Ir$$
$$E - V = r\left(\frac{V}{R}\right) \Rightarrow r = \frac{R}{V}(E-V) \longrightarrow ①.$$

Battery

- |||| +

K2   Galvanometer

R ( )

+   -   high R.B   G

E

Ammeter   A
+

Rhostat

Jockey

K₁

circuit Diagram for internal resistance of a cell

using the potentiometer, we can calculate E and V as follows -

$$E = K l_1 \quad\text{—} \quad ②$$
$$V = K l_2 \quad\text{—} \quad ③$$

where K is potential gradient along the wire and l_1 and l_2 are balancing lengths of potentiometer. substituting ②, ③ in ① we get -

$$V = \frac{R}{K l_2} \left(l_1 - l_2 \right) K$$

$$V = \frac{R}{l_2} \left(l_1 - l_2 \right) = R \left(\frac{l_1}{l_2} - 1 \right)$$

RESULT-

The internal resistance of the given cell is $0.81 \, \Omega$

PRECAUTIONS-

① current should be passed for short time.
② All connections should be neat, clean and tight.
③ Jockey should slid smoothly on the potentiometer wire.

SOURCES OF ERROR -

• The emf of battery is less than the cell.
• cell is distributed during the experiment.
• The potentiometer wire may not be of uniform area of cross section.

OBSERVATION TABLE-

S. NO.	Resistance = R (Ω)	Position of null pt.		Internal Resistance $r = \dfrac{R}{l_2}\left(\dfrac{l_1}{l_2}-1\right)$
		without shunt R, l_1	without shunt R, l_2	
1	2Ω	240 cm	310 cm	0.45Ω
2	3Ω	240 cm	318 cm	0.73Ω
3	5Ω	240 cm	321 cm	1.26Ω

CALCULATIONS-
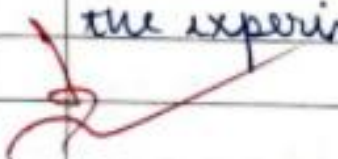
1) $r_1 = 2\left(\dfrac{240}{310}-1\right) = 0.45$

2) $r_2 = 3\left(\dfrac{240}{318}-1\right) = 0.73$

3) $r_3 = 5\left(\dfrac{240}{321}-1\right) = 1.26$

* mean value of $r = \dfrac{r_1+r_2+r_3}{3} = \dfrac{0.45+0.73+1.26}{3} = 0.81\Omega$

LEARNING OUTCOMES-

- Students get the idea of potentiometer apparatus and it's parts.
- Students are able to construct circuits based on circuit diagrams.
- Students understand the diff. component used in the experiment.

EXPERIMENT-6

AIM: To find the focal length of a convex lens by plotting graphs b/w 'u and v. or b/w $\frac{1}{u}$ and $\frac{1}{v}$

Apparatus Required - metre scale, convex lens with lens holder, ~~convex mirror (given)~~, optical bench with 3 uprights, ~~illuminated wire guage~~, 2 optical needles, a knitting needle and a half metre scale.

THEORY-

The relation b/w v and f for a convex lens is

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

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

$$\Rightarrow f = \frac{uv}{u-v}$$
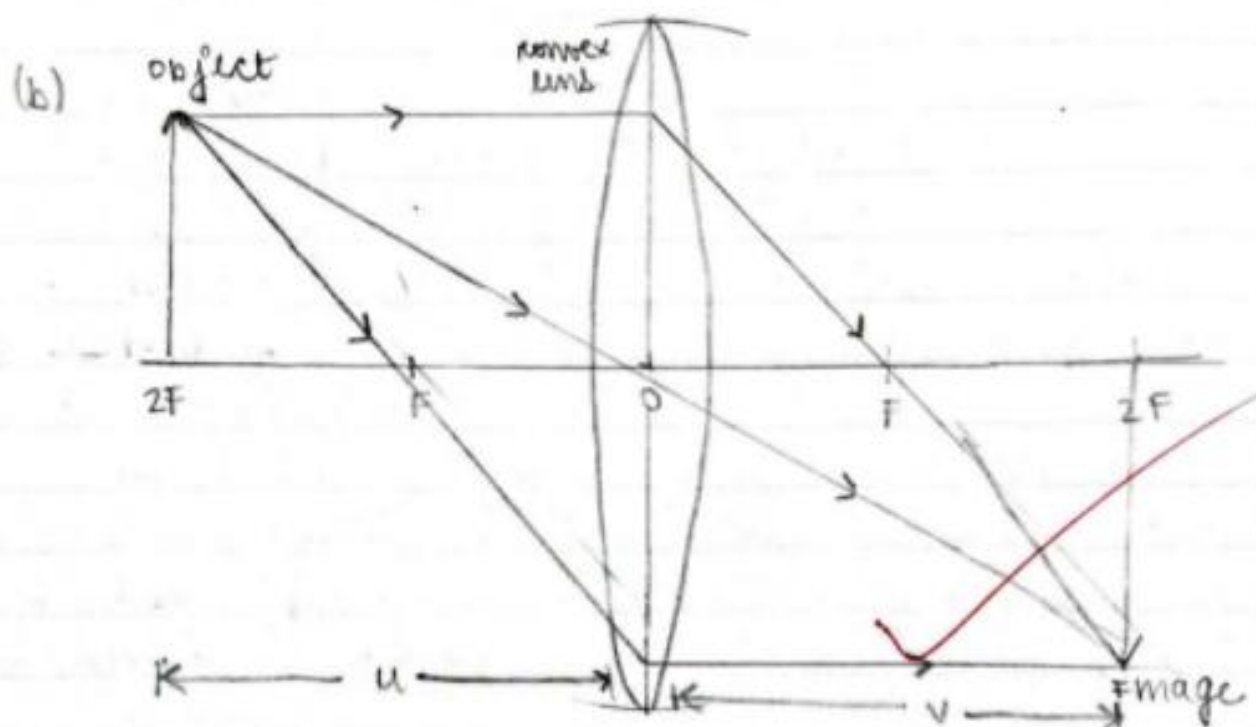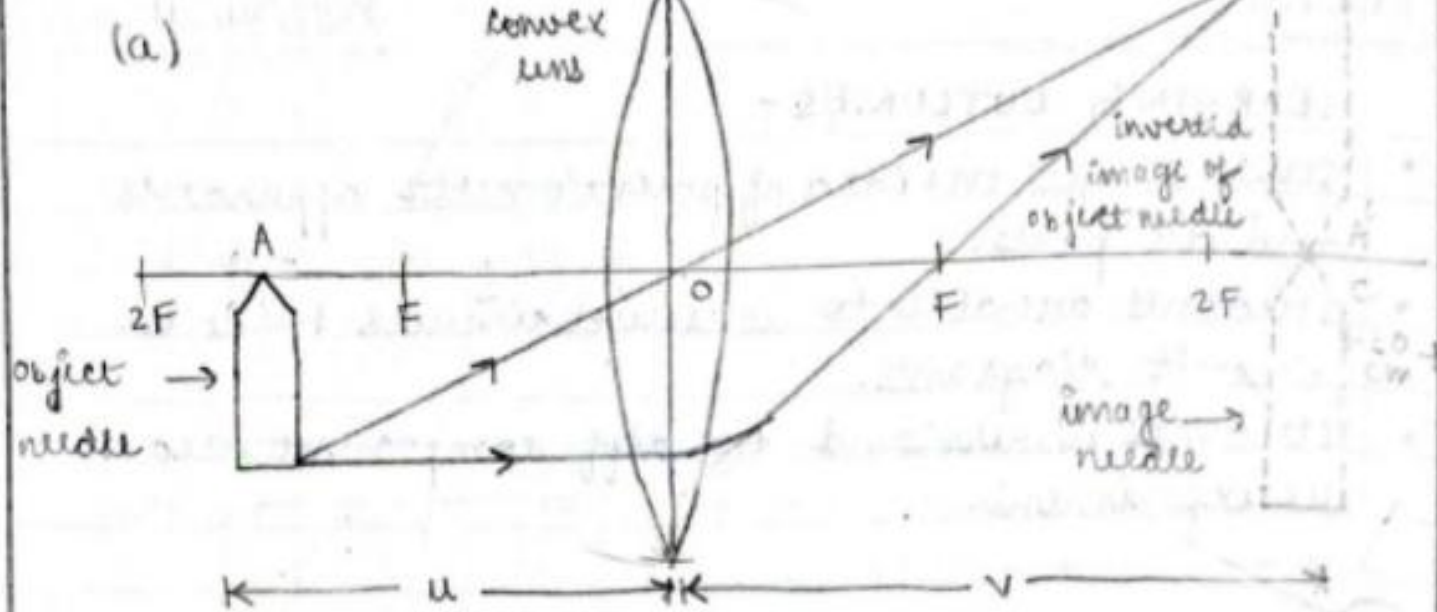
where f= focal length of the convex lens,
u= distance of the object needle from the optical centre of the lens.
v= distance of the image needle from the optical centre of the lens.

- value of f will be -ve, according the sign convention. u and v will have -ve values.

- Graph of u vs v is a hyperbola. when v=u then each equals 2f.

- when an object is placed in front of a thin convex lens at a dist. = 2f, a real and inverted image of same size

RAY DIAGRAM

(a)

convex lens

A

2F   F   O   F   2F

object needle

inverted image of object needle

image needle

$\longleftarrow u \longrightarrow$ $\longleftarrow v \longrightarrow$

(b)

object

convex lens

2F   F   O   F   2F

$\longleftarrow u \longrightarrow$ $\longleftarrow v \longrightarrow$ Image

Ray tracing for locating the image formed by
(a) convex lens
(b) convex lens of $u = 2F = v$

as that of object is formed at a distance equal to $2f$ on the other side of the lens.

Thus, by measuring the distances u and v, the focal length of the convex lens can be determined using the above eq^n.

RESULT-

The focal length of the given convex ~~mirror~~ lens from u–v graph is 7.5 cm.

LEARNING OUTCOME –

- students understand the following about convex lens: focal length and 2F, optical centre, focus / focal point.   principal axis.

PRECAUTIONS-

- The optical bench should be horizontal and all the uprights should be vertical.
- The eye should be atleast 25 cm away from the needle.
- The tip of the object, centre of the lens and the tip of the image should be at same height.
- The position of the convex lens should remain fixed throughout the experiment.

SOURCES OF ERROR-

- The uprights may not be vertical
- The parallax may not be removed properly.
- Index correction may not be applied properly.
- the optical bench may not be horizontal.

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■ LABORATORY READINGS

OBSERVATION TABLE

SNO	POSITION OF			CORRECTED DISTANCE	
	object needle A (cm)	Lens O (cm)	Image needle C (cm)	u (cm)	v (cm)
1	66	50	26	16	24
2	67	50	27	17	23
3	68	50	28	18	22
4	70	50	30	20	20
5	75	50	33	23	17
6	80	50	34	24	16

CALCULATION

* Draw graph b/w u and v from above points on x axis and y-axis.
* Draw angle bisector of x'OY which meets graph at P.
* The coordinates of P(2f,2f). Drop $\perp$s PA and PB on both the axis OX and OY. Focal length of the convex lens
  The distance OA = OB = 2f

$$f = \frac{OB}{2} = \frac{OA}{2}$$

$$= \frac{20.2}{2} = 10.1$$

scale
1 cm = 5 units → X axis
1 cm = 5 units → Y axis
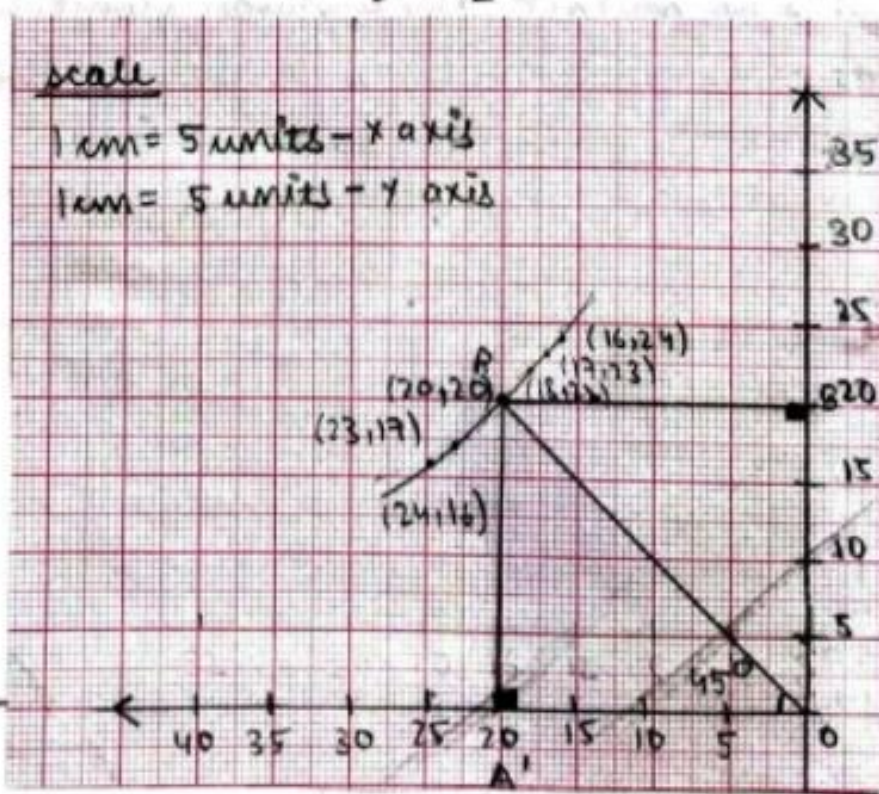
EXPERIMENT-7

AIM: To find the focal length of a concave lens using a convex lens.

APPARATUS REQUIRED: An optical bench with four uprights (two fixed uprights and two uprights with lateral movement), a convex lens of less focal length, a concave lens of more focal length, two lens holders, two optical needles (one thin and one thick), a knitting needle and a half meter scale.

THEORY:

A concave lens always forms a virtual image, therefore, its focal length can't be determined directly as for a convex lens. Therefore, its focal length is determined using a convex lens. If an object needle O is placed at one side of the convex lens L, at a distance greater than the focal length of the lens then its real and inverted image I^- is obtained on the other side of the object. If a concave lens L_2 is placed between lens L_1 and image I^-, then image I^- works as an object for the ~~convex~~ concave lens and its real image I is obtained.

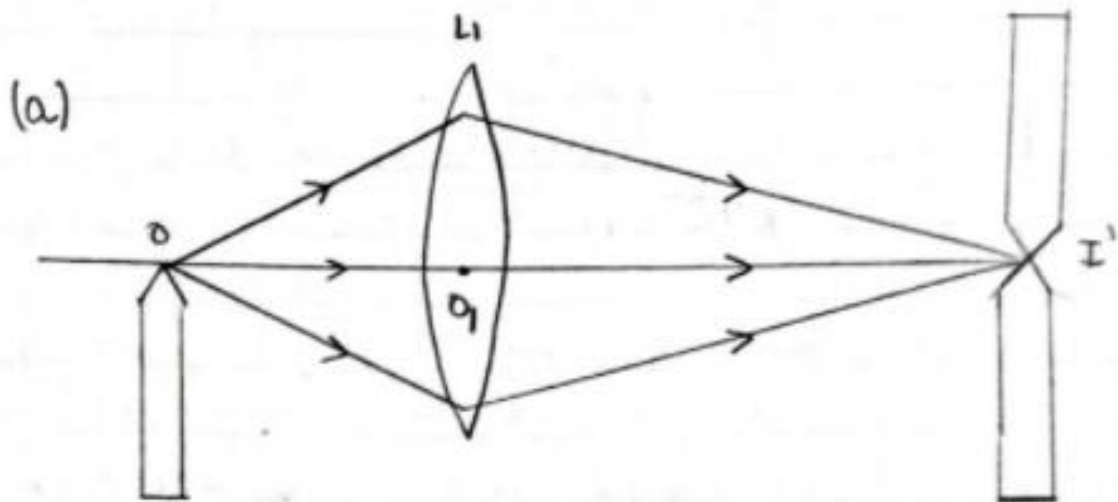For concave lens,

Object distance $(u) = L_2 I^1$

Image distance $(v) = L_2 I$
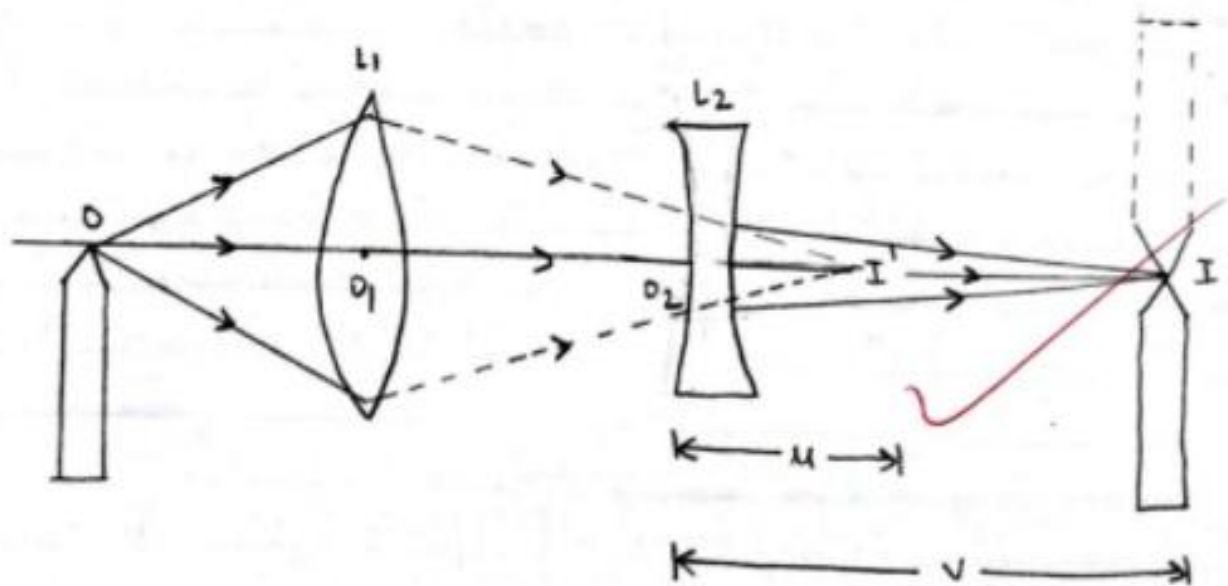
Focal length of the concave lens,

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

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

Teacher's Signature : _____

(a)

(b)

FOCAL LENGTH OF A CONCAVE LENS

OBSERVATION TABLE:

| S.NO. | Position of | | | | | corrected | | $f = \dfrac{uv}{u-v}$ |
	Object nedle o (cm)	convex lens L_1 (cm)	Image I (cm)	concave lens L_2 (cm)	Image I' (cm)	u (cm)	v (cm)	(cm)
1	29	50	75	69	78	6.0	9.0	-18.0
2	27	50	71.5	65	77.5	6.5	12.5	-13.54
3.	25	50	70.5	65	72.8	5.5	7.8	-18.65

calculations

1. (a) for Ist observation;
$$f_1 = \frac{uv}{u-v} = \frac{6 \times 9}{6-9} = \frac{\overset{2}{\cancel{6} \times 9}}{-\cancel{3}_1} = -18 \text{ cm}$$

(b) for IInd observation;
$$f_2 = \frac{uv}{u-v} = \frac{6.5 \times 12.5}{6.5 - 12.5} = \frac{81.25}{-6} = -13.54 \text{ cm}$$

(c) for IIIrd observation;
$$f_3 = \frac{uv}{u-v} = \frac{5.5 \times 7.8}{5.5 - 7.8} = \frac{42.9}{-2.3} = -18.65$$

2. mean focal length $(f) = \dfrac{f_1 + f_2 + f_3}{3} = \dfrac{-18 - 13.54 - 18.65}{3}$

$$= \frac{-50.19}{3}$$

$$= -16.73 \approx -17 \text{ cm}$$

RESULT:

The focal length of the given concave lens using convex lens is ___-17___ cm.

LEARNING OUTCOME:

■ students list the properties of concave lens.

■ students deduce and apply the lens formula.

■ students identify the two methods used to determine the focal length of concave lens.

PRECAUTIONS:

1. The optical bench should be horizontal.
2. The uprights should be rigid and vertical.
3. Tip to Tip parallax should be removed.
4. Focal length of the convex lens should be less than the focal length of the concave lens so that the combination is convex.
5. The tips of the needles should be sharp.

SOURCES OF ERROR:

1. the optical bench may not be horizontal.
2. The uprights may not be vertical.
3. lens may be thick.
4. uprights may be shaky.

Teacher's Signature : _____

EXPERIMENT – 8

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

MATERIALS REQUIRED:

Drawing Board, a white sheet of paper, a glass prism, drawing pins, a pencil, a half metre scale, office pins, a graph paper and a protractor.

THEORY:

The refractive index (n) of the material of the prism is given by:

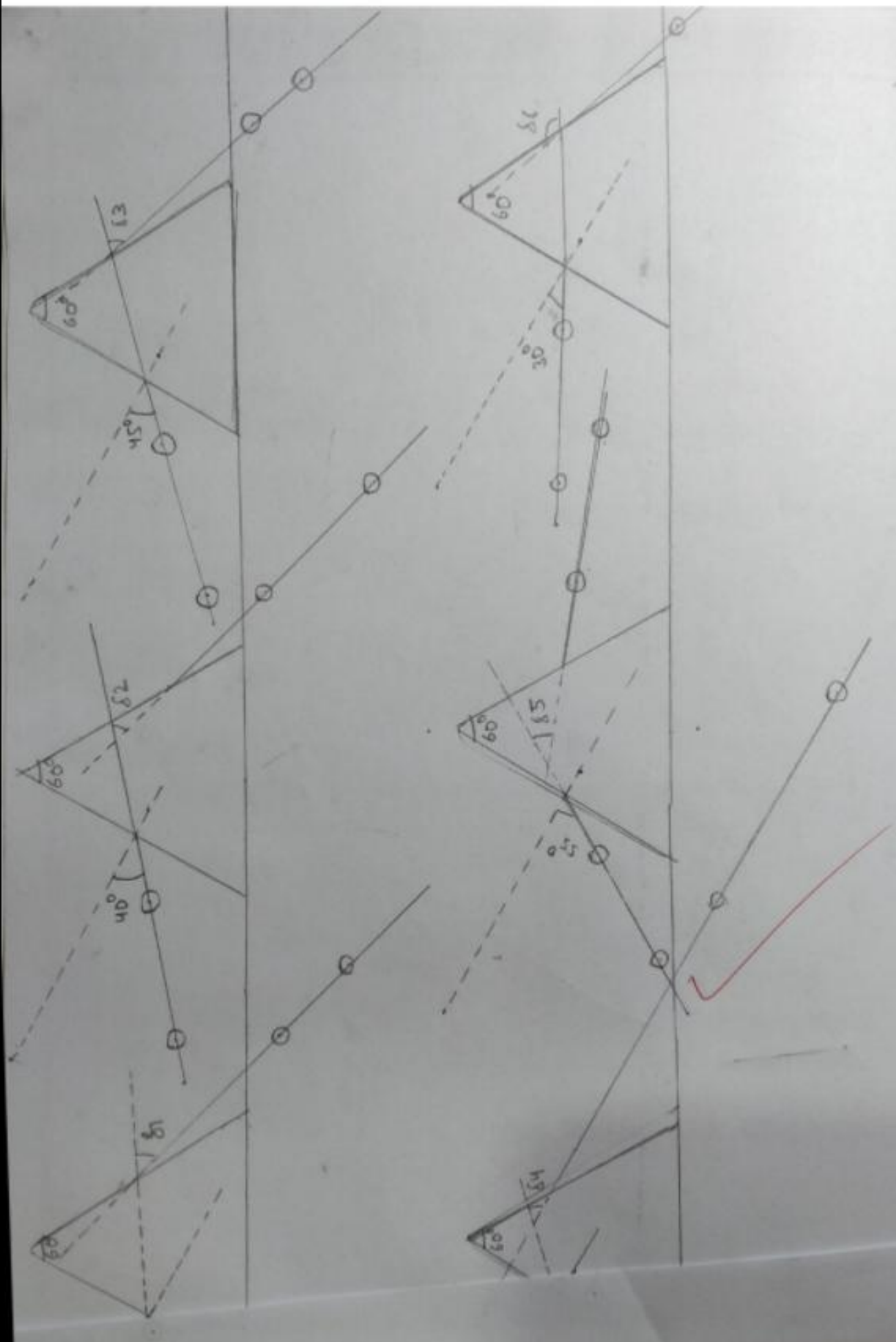$$\mu = \frac{\sin\left(\frac{A + \delta m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

where,

δm = angle of min deviation.

A = angle of the prism.

LEARNING OUTCOME:

■ Students learn to calculate the refractive index of the prism.

■ Students learn to apply the formula.

Teacher's Signature : _____

OBSERVATION TABLE

S. NO. of observations	Angle of incidence ($\angle i$)	Angle of deviation ($\angle \delta$)
1	$30°$	$50°$
2	$35°$	31
3	$40°$	$37.8°$
4	$41°$	$38°$
5	$49°$	$40°$
6	$60°$	$42°$

GRAPH BETWEEN ANGLE OF INCIDENCE ($\angle i$) AND ANGLE OF DEVIATION

scale:
X axis : 1 unit = $10°$
Y axis : 1 unit = $10°$

Angle of deviation (δ) →

Angle of incidence ($\angle i$)
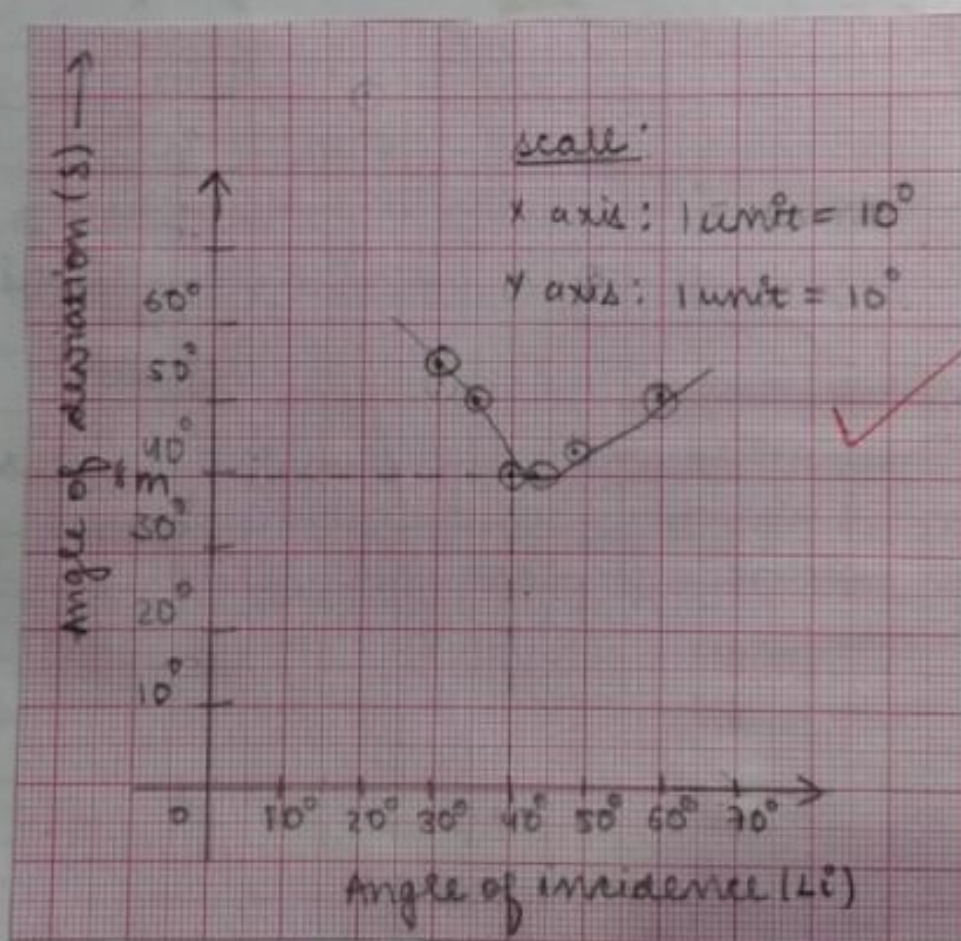
RESULT:

1. The graph between angle of incidence (i) and angle of deviation (δ) shows that as the angle of incidence increases gradually, the minimum angle of deviation decreases, attains a minimum value (δm) and then increases for further increase in angle of incidence.

2. The minimum angle of deviation, δm is _____.

PRECAUTIONS:

1. The angle of incidence should be between $35°$ to $60°$.
2. The pin should be fixed vertical.
3. The distance between two pins should be about $8-10$ cm.
4. The same angle of prism should be used for all the observations
5. Encircle the pin pricks after they are removed.
6. The curve should be free hand and smooth which would pass through the maximum no. of points.
7. The pencil which is used to draw boundary of the prism should be sharp.

SOURCES OF ERROR

1. The angle may not be measured properly.
2. The pin pricks may be thick.
3. The incident ray pins and emergent ray pins may not be along the same straight line.
4. The pins may not be exactly vertical.

Teacher's Signature : _____

EXPERIMENT – 9

AIM: TO determine the resistance of a galvanometer by half-deflection method and find its figure of merit.

APPARATUS REQUIRED:

A Weston type galvanometer, a battery or battery eliminator, two resistance boxes ($R = 10,000\,\Omega$ and $S = 500\,\Omega$), two one-way keys, a rheostat, connecting wires and a piece of sandpaper.

THEORY:

① The resistance of the galvanometer G by half deflection method is given by—

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

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

② Figure of merit of galvanometer is defined as the current required per division of deflection. It is denoted by 'K'.

Figure of merit of 'K' is given as—

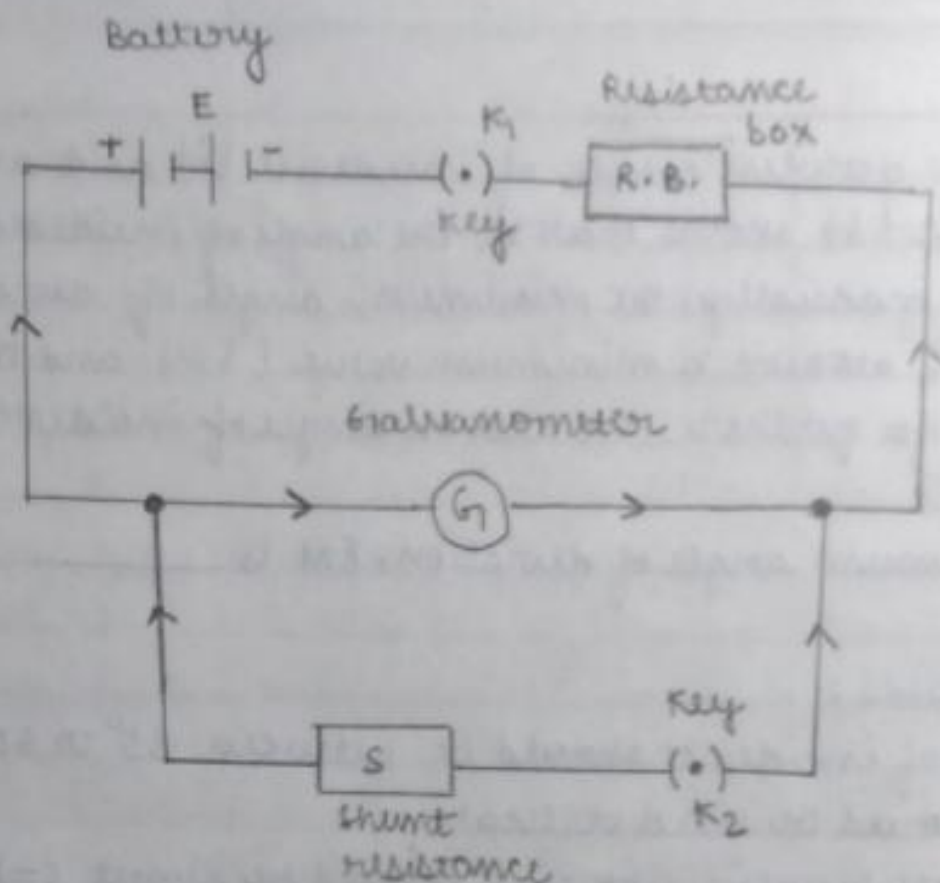$$K = \frac{I}{\theta} = \left(\frac{E}{R + G}\right) \cdot \frac{1}{\theta}$$

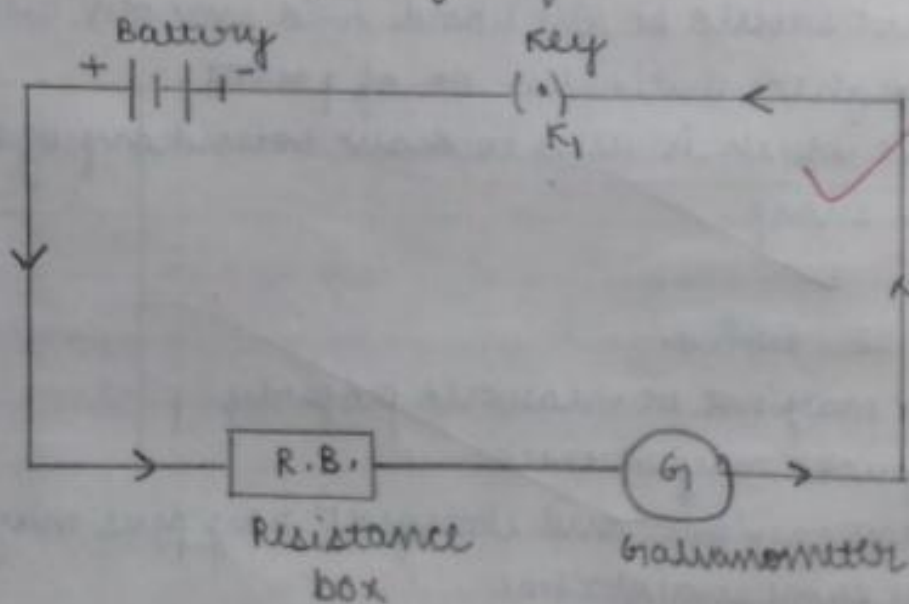**Fig 1:** circuit for the determination of resistance of a galvanometer by half deflection method

Fig 2: determination of figure of merit of the galvanometer

OBSERVATION TABLE

■ Resistance of the galvanometer by half deflection method

S.NO.	Resistance R(ohm)	Deflection in galvanometer θ (divisions) (m)	Half deflection θ/2 (divisions) ($\frac{m}{2}$)	Shunt resist -ance S (Ω)	Galvanometer Resistance $G = \frac{R \cdot S}{R - S}$ (ohm)
1	4500	30	15	70	71.1
2	9500	14	7	70	70.5
3	5200	26	13	70	70.9
4	5700	24	12	70	70.8

→ calculation of galvanometer resistance (G)

(a) calculate value of G using $\boxed{G = \frac{R \cdot S}{R - S}}$ for each observation

(b) mean value of galvanometer resistance

$$G = \frac{G_1 + G_2 + G_3 + G_4}{4} = \frac{71.1 + 70.5 + 70.9 + 70.8}{4} = 70.8 \ \Omega$$

■ Figure of merit

S.NO.	EMF of the cell E (Volt)	Resistance (R) ohm	Deflection (n) θ	Figure of merit $K = \frac{E}{(R+G)}$ (A/div)
1	1.5×2=3	4500	30	2.18×10^{-5}
2	3	9500	14	2.23×10^{-5}
3	3	5200	26	2.18×10^{-5}
4	3	5700	24	2.16×10^{-5}

→ mean of K = $\frac{(2.18 + 2.23 + 2.18 + 2.16) \times 10^{-5}}{4}$ = 2.19×10^{-5} A/div

where E is the emf of the cell and θ is the deflection produced in the galvanometer with resistance R.

LEARNING OUTCOMES-
- students understand the various components used in the experiment.
- students learn the concept, 'figure of merit'.
- students are able to construct circuits based on circuit diagrams.

RESULT
1. The resistance of the given galvanometer by half deflection method = $150 \ \Omega$
2. The figure of merit of the galvanometer $= 0.134 \times 10^{-4} \ A/div$

PRECAUTIONS
1. All connections should be neat, clean and tight.
2. All the plugs in resistance boxes should be tight.
3. The value of R should be adjusted in such a way that the deflection in galvanometer should be in large and in even number of divisions.
4. use a freshly charged battery so that its emf may remain constant throughout the experiment.

SOURCES OF ERROR
1. Plugs in resistance boxes may not be tight & have contact R.
2. calibration of resistance in resistance boxes may be wrong.
3. The emf of the battery may change during experiment.

Teacher's Signature : _____

EXPERIMENT-10

AIM: To convert the given galvanometer (of known resistance and figure of merit) into a voltmeter of a desired range and verify the same.

APPARATUS REQUIRED

A weston type galvanometer of known resistance and figure of merit, a battery, a rheostat, one-way key, a resistance box of the range $0-10,000\,\Omega$, a voltmeter of $0-3$ volt range, connecting wires, sandpaper.

THEORY

A galvanometer can be converted into a voltmeter of desired range by connecting a suitable high resistance R in its series.

Let G be the resistance of the galvanometer which gives full scale deflection when I_g current flows through it. Let V is the range of the voltmeter in which the galvanometer has to be converted and R is the resistance required to connect in series with the galvanometer, then resistance R is given by
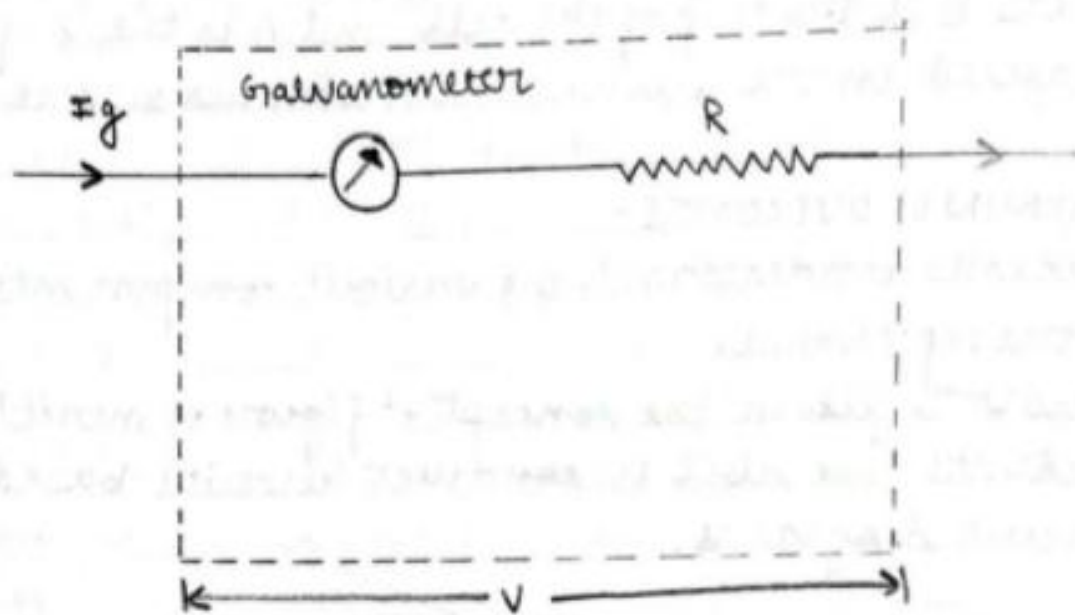
$$R = \frac{V}{I_g} - G$$

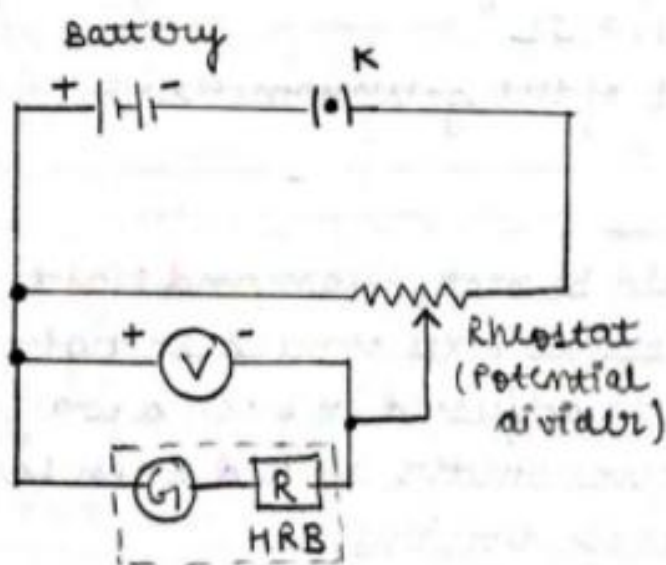FIG1 : conversion of a galvanometer into a voltmeter

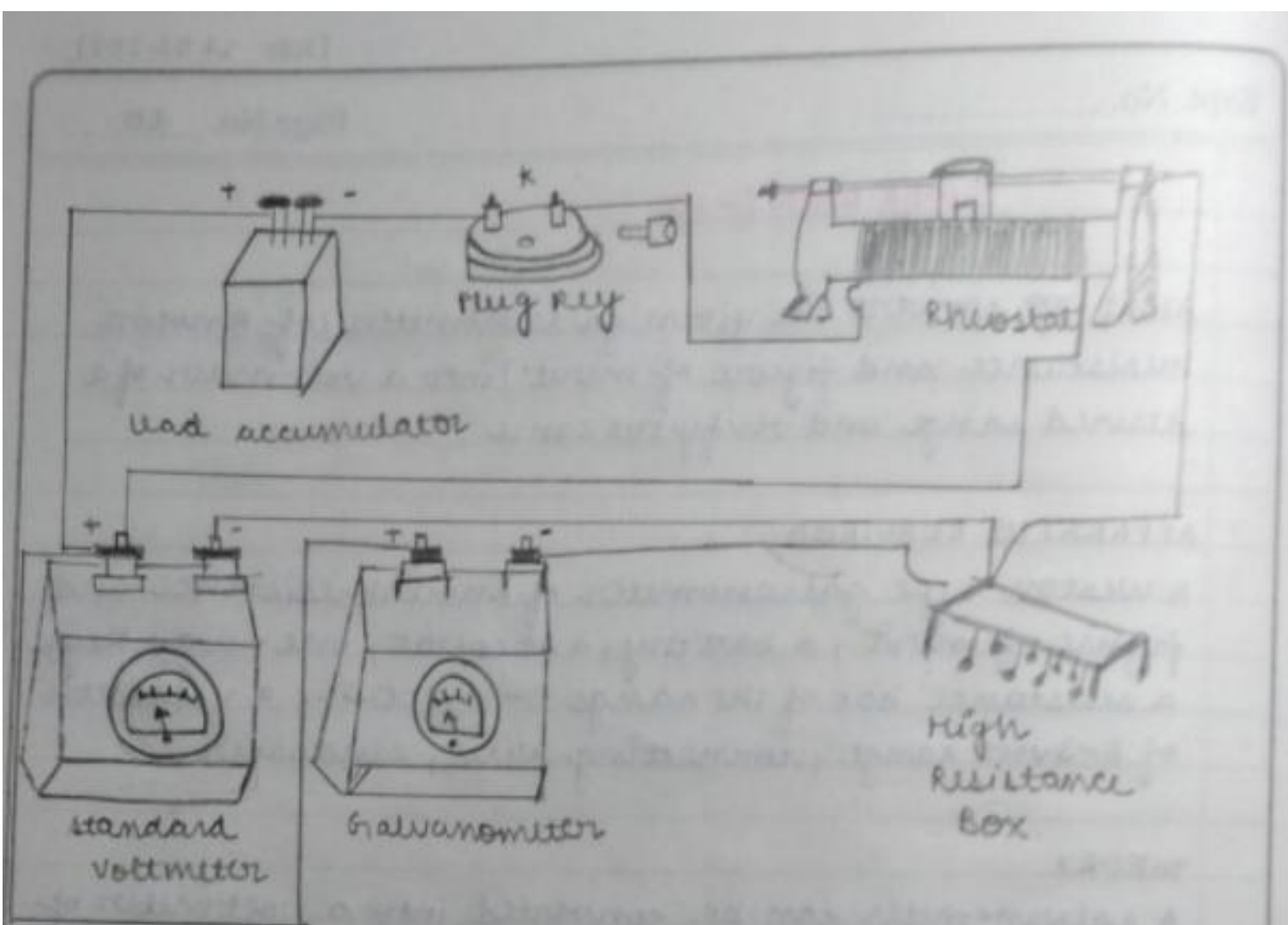FIG2 : circuit diagram for verifying and checking the accuracy of converted voltmeter.

FIG 3 : Experimental set-up for verification of a
converted voltmeter

LEARNING OUTCOME

■ The students learns the following concepts:
- galvanometer
- voltmeter
- figure of merit
- How a galvanometer can be converted into an voltmeter.

RESULT

1. The value of the required series resistance to be connected in series with the galvanometer to convert it into the voltmeter of the given range = _____ Ω.

2. Value of the current for full scale deflection I_g = _____ amp.

3. The difference between the values of standard voltmeter and converted voltmeter ie $(V_2 - V_1)$ is very small hence, conversion of given galvanometer into voltmeter of the given range is perfect.

PRECAUTIONS

1. The resistance box to be used in series should have a very high resistance as compared to resistance of galvanometer and that to be used in parallel should have a low resistance.

2. The deflection in galvanometer should be large.

3. The rheostat should be used as a potential divider.

4. The voltmeter used for verification should preferably be of the same order, as the range of conversion.

5. All plugs in the resistance box should be tight.

L.C. of new voltmeter

$$30 \text{ div} = 2V$$

$$1 \text{ div} = \frac{2}{30} V$$

$$\boxed{1 \text{ div} = \frac{1}{15} V}$$

OBSERVATION TABLE

SNO	V_0	n in new vom	least count (L.C.)	$V = n \times \frac{1}{15}$	$V - V_0$
1.	0.5	3	1/15	$V = \frac{3}{15} = \frac{1}{5}$ = 0.2	−0.3
2.	1	7	1/15	$V = \frac{7}{15}$ = 0.46	−0.54
3.	1.5	11	1/15	$V = \frac{11}{15}$ = 0.7	−0.8
4.	2	15	1/15	$V = \frac{15}{15} = 1$	−1

SOURCES OF ERROR

1. The e.m.f. of the battery may change during the experiment.

2. Calibration of resistance in resistance box may not be correct.

3. Plugs in resistance box may not be tight and may have contact resistance.

4. the galvanometer divisions may not be of equal size.

EXPERIMENT - 11

AIM: To find the focal length of a convex ~~lens~~ mirror using a convex lens.

APPARATUS REQUIRED:

An optical bench with four uprights (two fixed uprights in middle, two outer uprights with lateral movements), convex lens (20 cm focal length), convex mirror, a lens holder, a mirror holder, two optical needles (one thin and one thick), a knitting needle and a half metre scale.

THEORY

A convex mirror always forms a virtual image, therefore its focal length can't be determined directly as for a concave mirror. For this purpose, a convex lens is used to measure the focal length of the convex mirror.

A convex lens L is placed b/w the object needle O and convex mirror M. Keeping the position of M and O fixed the lens is adjusted to remove the parallax. In this position, light rays are incident normally on the mirror. The position of centre of curvature C of the mirror is obtained by removing the mirror and obtaing the image of the object needle I' at the position of image needle.
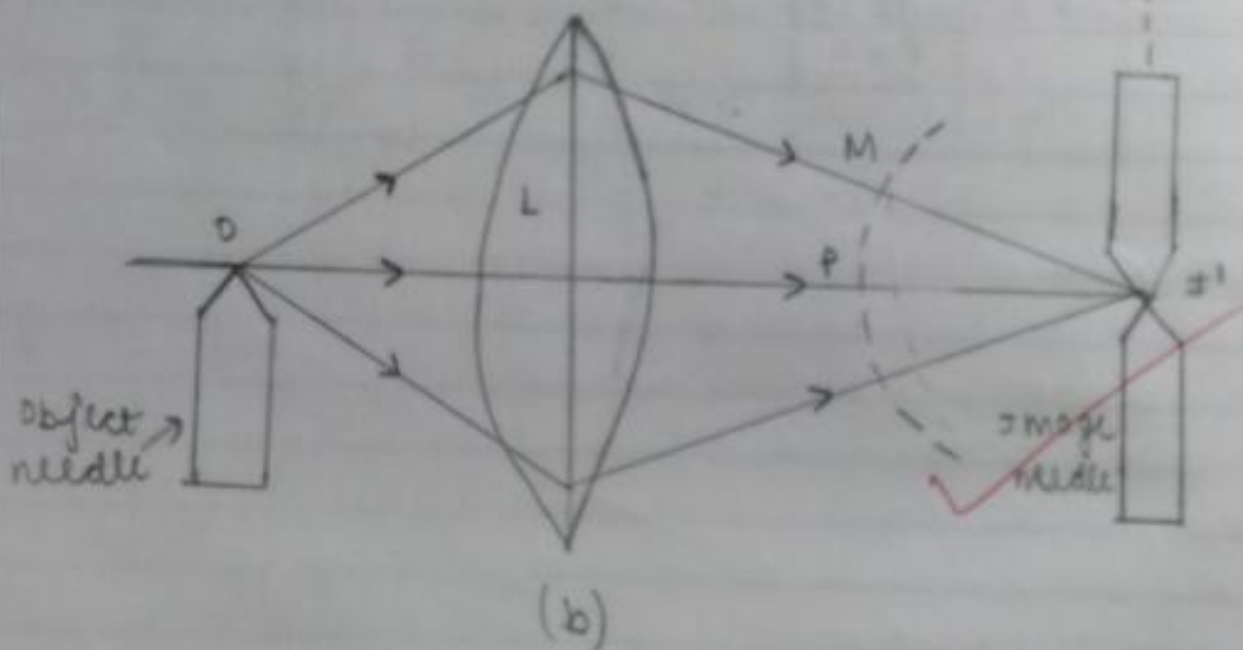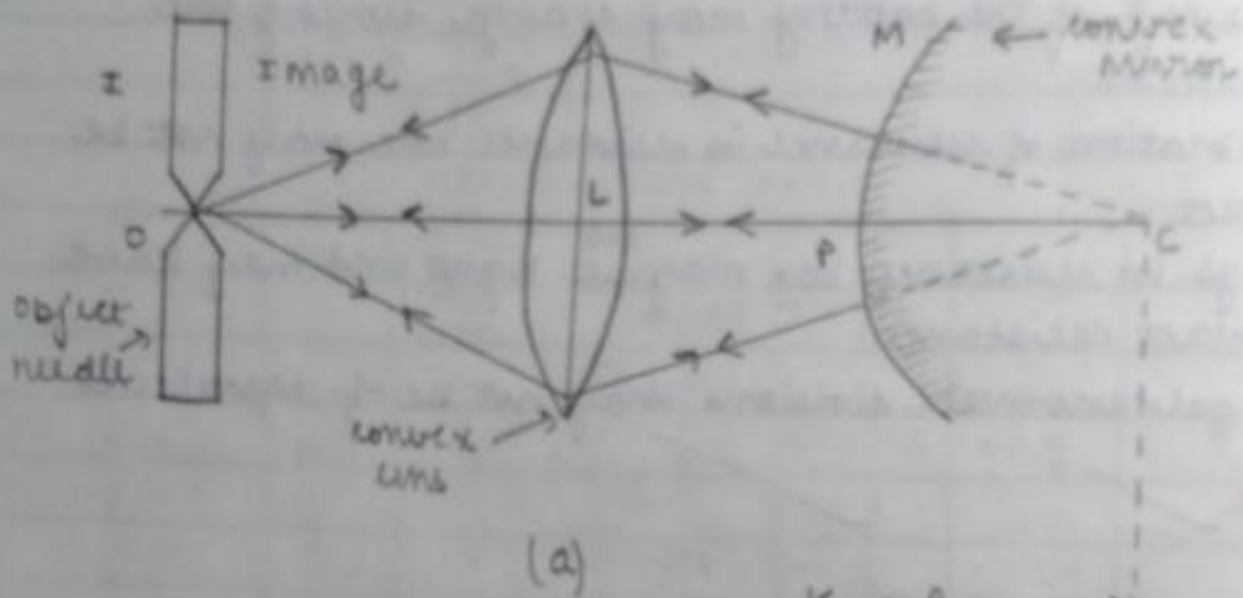
RAY DIAGRAM

(a)

(b)

FIG1 : Focal length of convex mirror using convex lens

OBSERVATION TABLE

S. NO.	POSITION OF				Radius of curvature MI (cm)
	object needle (0) cm	lens L cm	Mirror M (cm)	Image needle I (cm)	
1	25	50	56	70.5	14.5
2	28.5	50	60	73.3	13.3
3	31.5	50	65	78.4	13.4
4	30.5	50	60	74	14

$$\text{mean } R = \frac{14.5 + 13.3 + 13.4 + 14}{4} = 13.8$$

$$f = \frac{R}{2} = \frac{13.8}{2} = \underline{6.9 \text{ cm}}$$

Radius of curvature $R = PC = PI'$

$\therefore$ Focal length of the mirror $f = \dfrac{R}{2}$

LEARNING OUTCOMES:

Students understand the following terms:
- convex mirror
- focal point
- Radius of curvature

RESULT

The focal length of the given convex mirror by using convex lens is 6.9 cm.

PRECAUTIONS

1. The optical bench should be horizontal and all the upright should be vertical.
2. The tip of the needle, centre of the mirror and the centre of the lens should be at same hieght.
3. Tip to Tip parallax should be removed carefully and while removing the parallax the eye should be kept at least 30 cm from the needle.
4. The convex lens L should have sufficiently large focal length.
5. convex mirror shoulde be placed close to the convex lens.
6. Index correction should be applied b/w I' and back surface of the mirror.
7. The position of lens and object needle shouldn't be changed.

SOURCES OF ERROR

1. The uprights may not be vertical.
2. The parallax removal may not be perfect.
3. Index correction may not be applied properly.

EXPERIMENT-12

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

APPARATUS REQUIRED:

A semiconductor p-n junction diode, a milliammeter of range 0-50 mA, a microammeter of range 0-500 μA, two variable power supplies (0-3 V and 0-15 V), two voltmeters of ranges 0-3V and 0-15 V, one-way key, connecting wires.

THEORY:

A p-n junction is said to be forward biased when its p-region is connected to positive terminal of the battery and n-region to the negative terminal of the battery.
A p-n junction is said to be reverse biased when its p-region is connected to negative terminal of the battery and n-region to the positive terminal of the battery.
I-V characteristics of a p-n junction diode are the graphs showing the variation of current as a function of ~~voltage~~ applied voltage.

In forward biasing, the forward current increases very slowly in the beginning with increase in forward voltage upto a definite forward voltage called knee voltage. After that forward current increases significantly with increase in forward voltage.
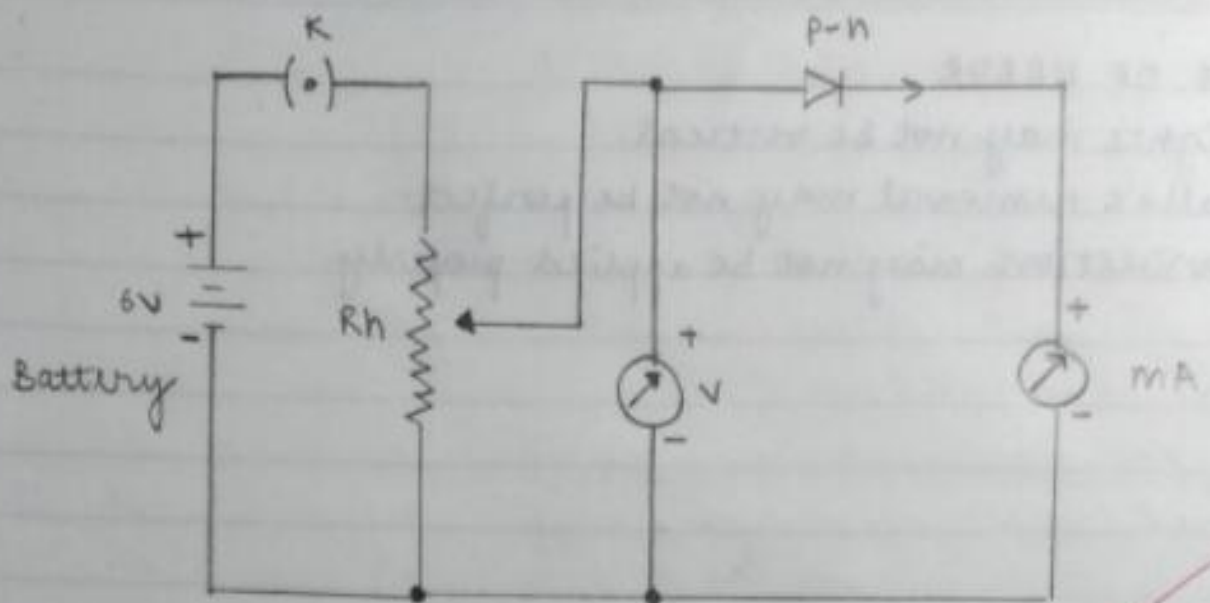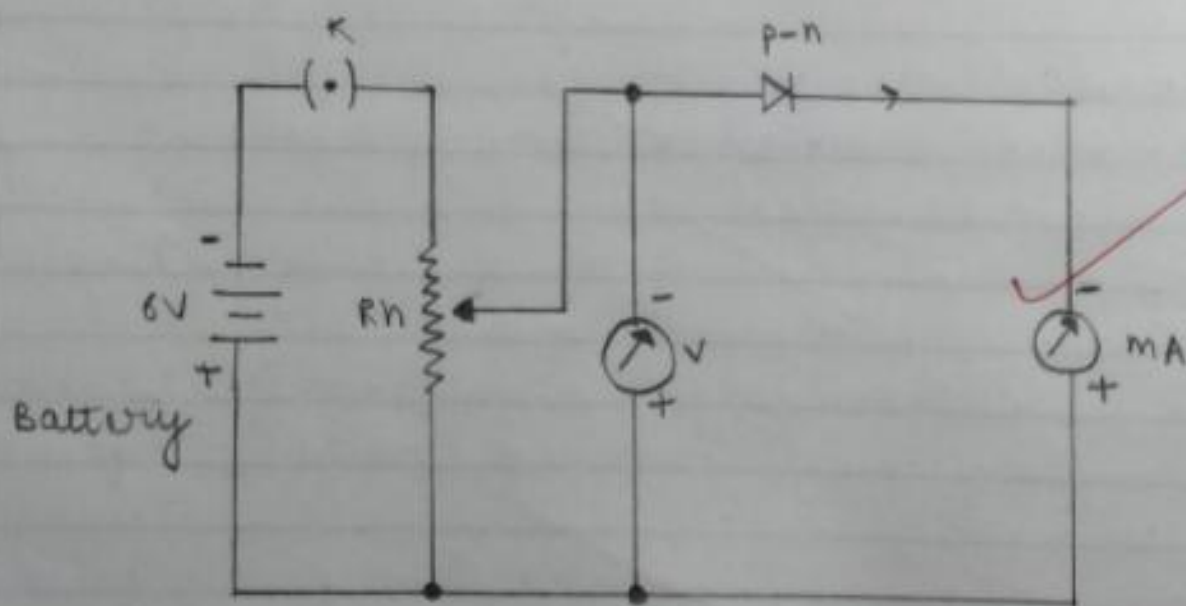
Fig 1: Forward bias circuit of a p-n junction diode.

Fig 2: Reverse Bias circuit of p-n junction diode

In reverse biasing, the reverse current remains almost zero and doesn't increase with increase in reverse voltage upto a sufficient long range of reverse voltage. At a definite reverse voltage called zenner voltage or breakdown voltage, the covalent bonds near the junction start to break due to which reverse current increases abruptly which can't be controlled by decreasing reverse voltage. This phenomenon is called AVALANCHE BREAKDOWN.

RESULT

① The forward bias and reverse bias characteristics of the given p-n junction diode are shown on the graph paper.

② The I-V characteristic curve of a p-n junction diode is not a straight line, therefore, diode is non-ohmic in nature.

③ In forward bias, the dynamic resistance is $0.15\,\Omega$

④ In reverse bias, the dynamic resistance is $10\,\Omega$

PRECAUTIONS

① The plug of the key should be inserted only when the circuit is in use.

② Voltmeters & ammeters of app. least count & ranges to be selected.

③ In forward biasing, a milliammeter and in reverse biasing, microammeter should be used.

④ Voltage applied should not exceed the max. allowed limit (breakdown voltage) of the given diode.

⑤ Terminals of voltmeter & ammeter should be connected to battery in the right manner.

Range of voltmeter 0-1v L.C.=0.02

Range of Ammeter 0-10mA L.C.=0.4

OBSERVATION TABLE

S. No.	FOR FORWARD BIASING		FOR REVERSE BIASING	
	Forward bias voltage V_f (in V)	Forward current (I_f)	Reverse bias voltage (V_r)	Reverse current (I_r)
1.	0.1	0	1	0
2.	0.2	0	2	0
3.	0.3	0.8	3	0
4.	0.4	1.2	4	0.1
5.	0.5	2	5	0.2
6.	0.6	2.8	6	0.4
7.	0.7	3.6	7	0.5
8.	0.8	4.2	8	0.6
9.	0.9	5.6	9	0.8
10.	1	6.4	10	1

CALCULATIONS

1. Plot a graph b/w forward voltage V_f and forward current I_f taking V_f along x-axis and I_f along Y-axis. The obtained graph is the forward bias characteristic of p-n junction diode

2. Plot the graph between reverse voltage V_r and reverse current I_r taking V_r along negative x axis and I_r along

forward bias
$$\Delta R = \frac{\Delta V}{\Delta I} = \frac{0.5 - 0.2}{2 - 0} = \frac{0.3}{2} = 0.15\,\Omega$$
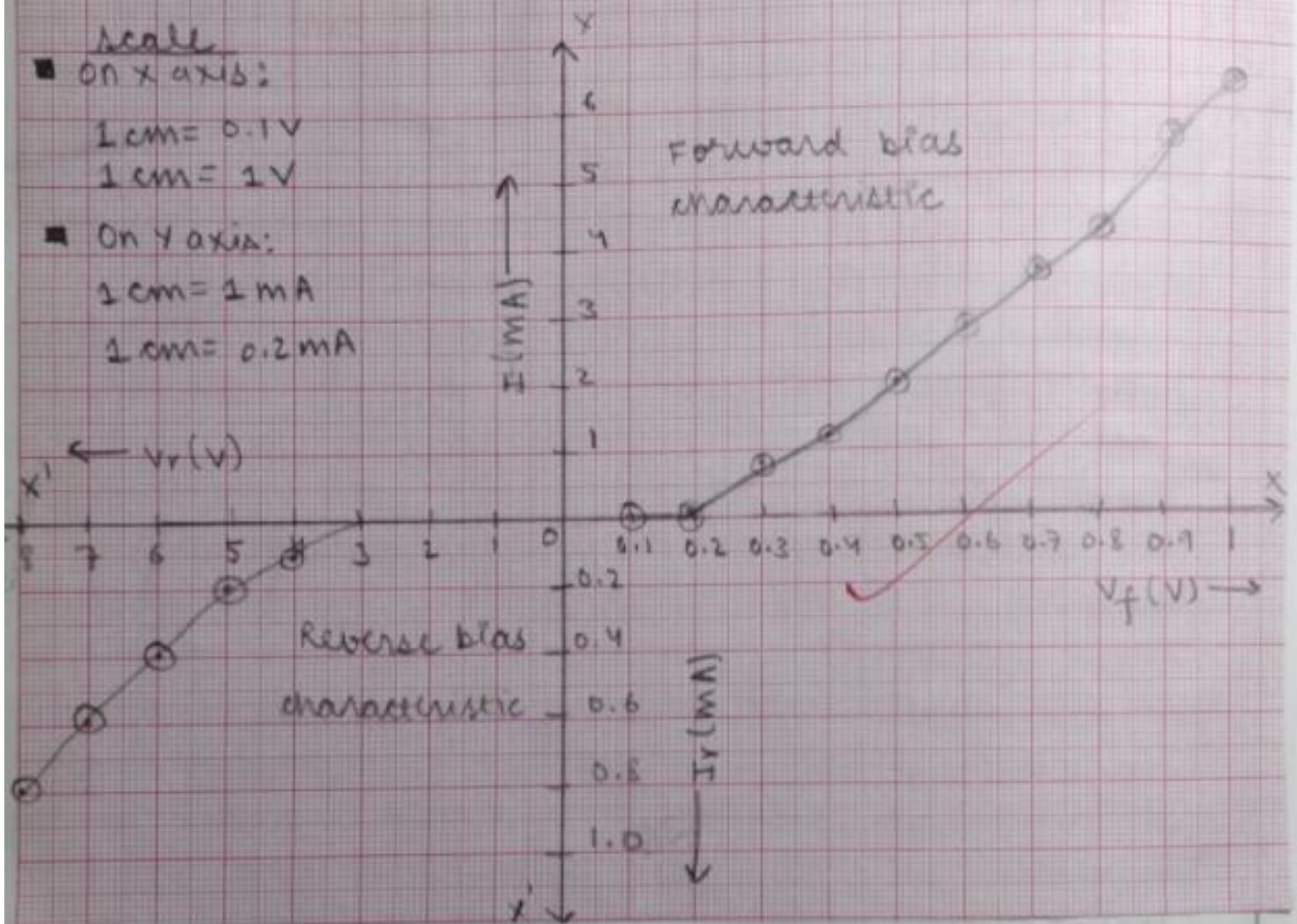
scale
- On x axis:
  1 cm = 0.1 V
  1 cm = 1 V
- On Y axis:
  1 cm = 1 mA
  1 cm = 0.2 mA

← Vr (V)

Forward bias characteristic

Reverse bias characteristic

$$\Delta R = \frac{\Delta V}{\Delta I} = \frac{5-3}{0.2-0} = \frac{2}{0.2} = 10\,\Omega$$
(Reverse bias)

FORWARD AND REVERSE BIAS CHARACTERISTICS OF
P-n JUNCTION DIODE

SOURCES OF ERROR

1. connections may not be tight
2. voltmeter and ammeter of appropriate least count and range may not be selected.
3. The terminals of ~~voltage~~ voltmeter and ammeter may not be connected properly.