PHYSICS **EXPERIMENT – 1**

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

Apparatus: A metallic conductor (coil or a resistance wire), a battery, one way key, a voltmeter and an ammeter of appropriate range, connecting wires and a piece of sand paper, a scale.

Formulae Used: The resistance (R) of the given wire (resistance coil) is obtained by Ohm's Law $\frac{V}{I} = R$

Where, V : Potential difference between the ends of the given resistance coil. (Conductor)

I: Current flowing through it.

If l is the length of resistance wire, then resistance per cm of the wire = $\frac{R}{l}$

Observation:

(i) Range:

Range of given voltmeter = 3 v

Range of given ammeter = 500 mA

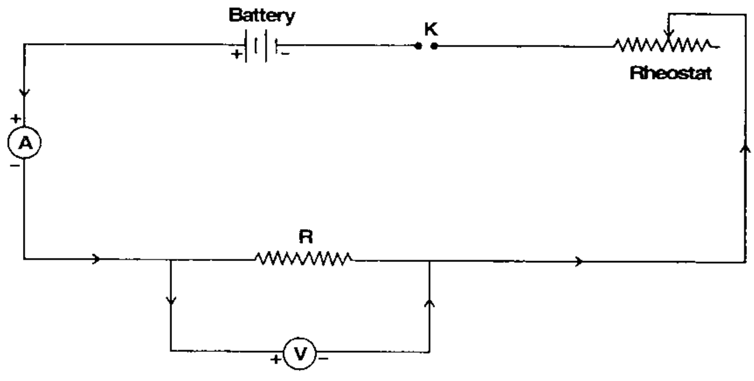


Fig. 1.1

(ii) Least count:

Least count of voltmeter = 0.05v

Least count of ammeter = 10 mA

(iii) Zero error:

Zero error in ammeter, $e_1 = 0$

Zero error in voltmeter, $e_2 = 0$

Ammeter and Voltmeter Readings:

Sr. No.	Ammeter Reading I (A)		Voltmeter Reading, V (v)		$\frac{V}{I} = R$
	Observed	Value	Observed	Value	
1	50	500 mA	16	16x0.05=0.8	1.6 Ω
2	35	350 mA	11	0.55	1.57 Ω
3	32	320 mA	10	0.50	1.56 Ω
4	19	190 mA	6	0.30	1.58 Ω
5	10	100 mA	3	0.15	1.5 Ω

Mean R = 1.56

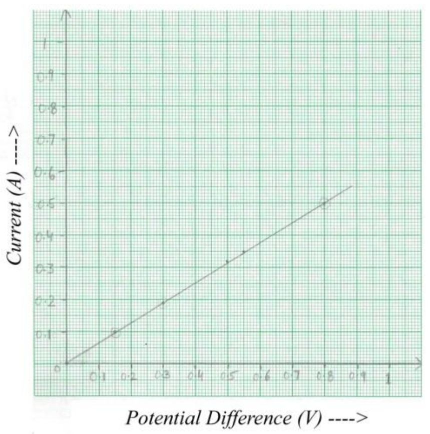
Length of resistance wire: 28 cm

Graph between potential difference & current:

Scale: X – axis : 1 cm = 0.1 V of potential difference

Y – axis: 1 cm = 0.1 A of current

The graph comes out to be a straight line.



Result: It is found that the ratio V/I is constant, hence current voltage relationship is established i.e. V $\propto$ I or Ohm's Law is verified.

Unknown resistance per cm of given wire = 5.57 x $10^{-2}\,\Omega\,cm^{-1}$

Precautions: Voltmeter and ammeter should be of proper range.

- The connections should be neat, clean & tight.

Source of Error: Rheostat may have high resistance.

The instrument screws may be loose.

EXPERIMENT – 2

Aim: To find resistance of a given wire using Whetstone's bridge (meter bridge) & hence determine the specific resistance of the material.

Apparatus: A meter bridge (slide Wire Bridge), a galvanometer, a resistance box, a laclanche cell, a jockey, a one-way key, a resistance wire, a screw gauge, meter scale, set square, connecting wires and sandpaper.

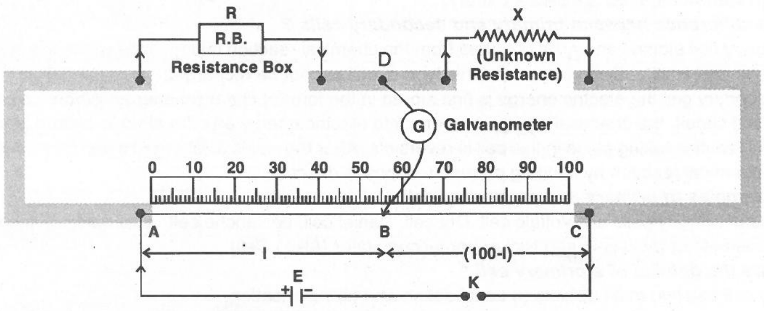


Fig. 2.1 Circuit Diagram - Meter Bridge

Formulae Used:

(i) The unknown resistance X is given by:

X = $\frac{(100-l)}{l}\times R$ Where,

R = known resistance placed in left gap.

X = Unknown resistance in right gap of meter bridge.

l=length of meter bridge wire from zero and upto balance point (in cm)

(ii) Specific resistance (ρ) of the material of given wire is given $\rho = \frac{X\pi D^2}{4L}$

Where,

D: Diameter of given wire **L**: Length of given wire.

Observation Table for length (*l*) & unknown resistance, X:

Sr. No.	Resistance from resistance box R (ohm)	Length AB = *l* cm	Length BC = (100-l) cm	Unknown Resistance X = R. $\frac{(100-l)}{l}\Omega$
1	2	41	59	2.87
2	4	60	40	2.66
3	6	69	31	2.69
4	8	76	24	2.52

Table for diameter (D) of the wire:

Sr. No.	Linear Scale Reading (N) mm	Circular Scale Reading		Observed diameter D = N + n x L.C. mm
		No. of circular scale divisions coinciding (n)	Value n x (L.C.) mm	
1	0	34	0.34	0.34
2	0	35	0.35	0.35
3	0	36	0.36	0.36
4	0	35	0.35	0.35

Observations:

- Least count of screw gauge: 0.001 cm

Pitch of screw gauge: 0.1 cm

Total no. of divisions on circular scale: 100

Least Count = $\dfrac{Pitch}{No.\,of\ \ divisions\ on\ circular\ \ scale}$

$\therefore LC = 0.001\,cm$

- **Length of given wire, L = 25cm**

  Calculation:
- For unknown resistance, X:

  Mean X = $\dfrac{X_1 + X_2 + X_3 + X_4}{4} = 2.68\Omega$
- Mean diameter, D = $\dfrac{D_1 + D_2 + D_3 + D_4}{4} = 0.035\,cm$
- Specific Resistance, $\rho = X.\dfrac{\pi D^2}{4L} = 1.03\times10^{-4}\,\Omega\,cm$

Result: Value of unknown resistance = 2.68 Ω

Specific resistance of material of given wire $= 1.03\times10^{-4}\,\Omega\,cm$

Precautions: All plugs in resistance box should be tight. Plug in key, K should be inserted only while taking observations.

Sources of Error: Plugs may not be clean.

Instrument screws maybe loose.

EXPERIMENT – 3

Aim: To verify the laws of combination (series & parallel) of resistances using meter bridge (slide Wire Bridge)

Apparatus: A meter bridge, laclanche cell, a galvanometer, a resistance box, a jockey, two resistances wires, set square, sand paper and connecting wires.

(i) In series

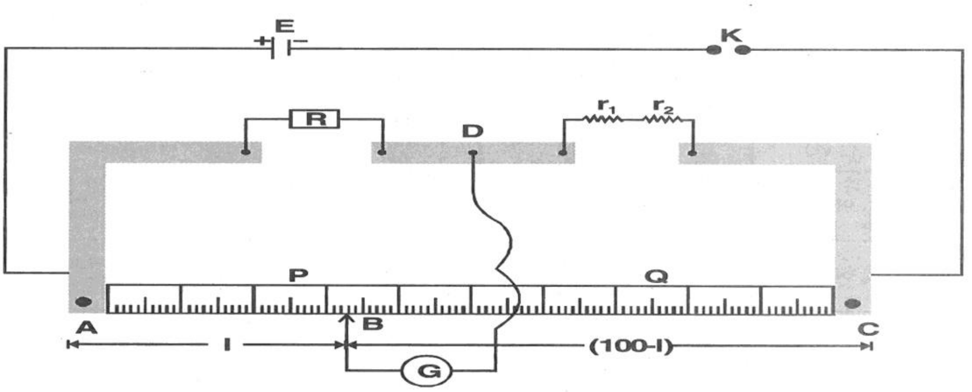


Fig. 3.1 Series combination of resistances

(ii) In parallel

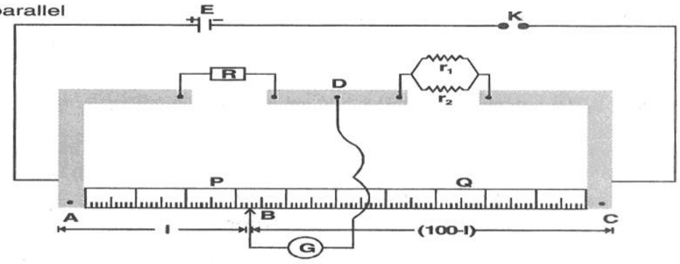


Fig. 3.2 Parallel combination of resistances

Observations: Table for length (l) & unknown resistance (r):

Resistant Coil	Obs. No.	Resistance from resistance box, R (ohm)	Length AB = l (cm)	Length BC = 100 – l (cm)	Resistance $r = \frac{100-l}{l}.R$	Mean Resistant (ohm)
r_1 only	1	0.5	35	65	0.92	
	2	1.0	43	57	1.32	1.24
	3	1.5	50	50	1.5	
r_2 only	1	0.5	30	70	1.16	
	2	1.0	38	62	1.63	1.51
	3	1.5	46	54	1.76	
r_1 & r_2 in series	1	1.3	34	66	2.52	
	2	2.2	45	55	2.68	2.72
	3	3.5	54	46	2.97	
r_1 & r_2 in parallel	1	2	75	25	0.67	
	2	3	82	18	0.66	0.66
	3	4	86	14	0.65	

Calculations:

(i) In Series: Experimental value of R_S = 2.72 Ω

Theoretical value of $R_S = r_1 + r_2 = 2.75\ \Omega$

(ii) In parallel: Experimental value of R_P = 0.66 Ω

Theoretical value of $R_P = \frac{r_1 r_2}{r_1 + r_2} = 0.68\Omega$

Result: Within limits of experimental error, experimental & theoretical values of R_S are same. Hence the law of resistance in series i.e. $R_S = r_1 + r_2$ is verified. (1) Within limits of experimental error, experimental & theoretical values of R_P are same. Hence law of resistances in parallel i.e. $R_S = \frac{r_1 r_2}{r_1 + r_2}$ is verified.

Precautions:

(i) The connections should be neat, clean & tight.

(ii) Move the jockey gently over the wire & don't rub it.

(iii) All plugs in resistant box should be tight.

Sources of Error:

(i) The plugs may not be clean.

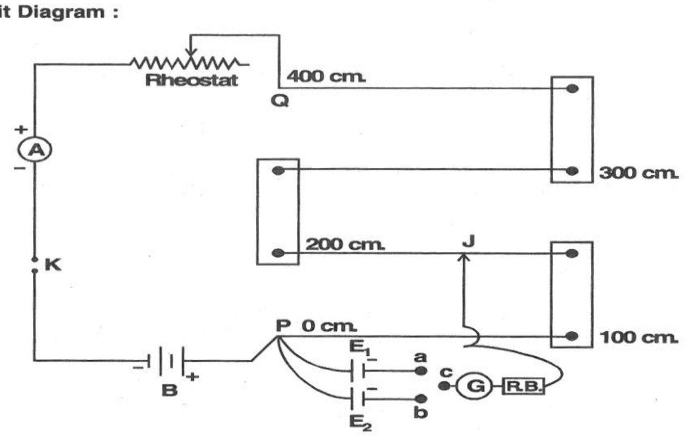
(ii) The instrument screws maybe loose.

EXPERIMENT – 4

Aim: To compare the E.M.F.'s of two given primary cells using a potentiometer.

Apparatus: A potentiometer, a laclanche cell, a Daniel cell, an ammeter, a voltmeter (0-5v), a galvanometer, a battery (or battery eliminator), a rheostat of law resistance, a resistance box, a one-way key, a two-way key, a jockey, a set square, connecting wires and a piece of sand paper.

Circuit Diagram :



Observations:

Fig. 4.1 : Comparison of e.m.f.'s of two cells

Range of voltmeter: 5V
Least count of voltmeter: 0.05V
E.M.F. of battery E: 3V
E.M.F. of Laclanche Cell, E_1: 1.45V
E.M.F. of Daniel Cell, E_2: 1.125V

Table for Lengths:

S. No.	Balancing length when E_1 (Leclanche Cell) is in the circuit (cm) (l_1)	Balancing length when E_2 (Daniel Cell) is in circuit (cm) (l_2)	Ratio $\frac{E_1}{E_2} = \frac{l_1}{l_2}$
1	558	437	558/437 = 1.277
2	789	617	1.278
3	848	670	1.266
4	893	706	1.265
5	662	521	1.270

Calculations: Mean $\frac{E_1}{E_2} = 1.271$ (Unit less)

Result: The ratio of E.M.F.'s $\frac{E_1}{E_2} \approx 1.27$

Precautions:

(i) The connections should be neat, clean & tight.
(ii) The positive poles of the battery E and cells E_1 and E_2 should all be connected to the terminals at the zero of the wires.
(iii) The jockey should not be rubbed along the wire. It should touch the wire gently.

Sources of Error:

(i) The auxiliary battery may not be fully charged.
(ii) The potentiometer wire may not be of uniform cross-section and material density throughout its length.
(iii) Heating of potentiometer wire by current, may introduce some error.

EXPERIMENT – 5

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

Apparatus: A potentiometer, a battery, two one-way keys, a rheostat of law resistance, a galvanometer, a high resistance box, a fractional resistance box (1-10Ω), an ammeter, a voltmeter (0-5V), a cell, a jockey, a set square, connecting wires & piece of sand paper.

Circuit Diagram :

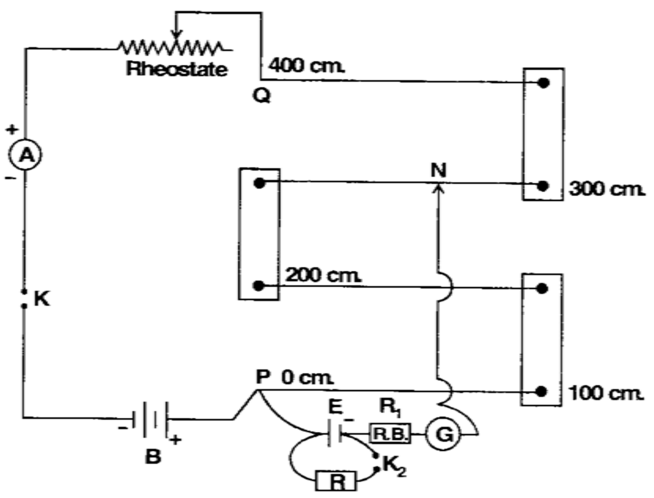


Fig. 5.1 : Internal Resistance of a Cell

Observations:

(i) EMF of battery = 2V

EMF of cell = 1.35V

(ii) Table for lengths:

Sr. No.	Position of Null pt (cm)		Value of shunt resistance R (Ω)	Internal resistance
	Without shunt R, l_1 cm	With shunt R_1, l_2 cm		$r = \left(\frac{l_1 - l_2}{l_2}\right) R\,\Omega$
1	571	67	1	7.53
2	619	91	1.5	8.10
3	689	129	2	8.68
4	749	196	2.5	7.05
5	882	221	3	8.97
6	950	289	3.5	7.9

Result: The internal resistance of the given cell is 8.11 Ω

Precautions:

(i) The EMF of the battery should be greater than that of cell.

(ii) For one set of observations, the ammeter reading should remain constant.

(iii) Rheostat should be adjusted so that initial will point lies on last wire of potentiometer.

Sources of Error:

(i) The auxiliary battery may not be fully charged.

(ii) End resistance may not be zero.

(iii) Heating of potentiometer wire by current, may introduce some error.

EXPERIMENT – 6

Aim: To determine the resistance of a galvanometer by half-deflection method & to find its figure of merit.

Apparatus: A Weston type galvanometer, a voltmeter, a battery, a rheostat, two resistance boxes (10,000 Ω and 500 Ω), two one-way keys, a screw gauge, a meter scale, connecting wires and a piece of sandpaper.

Circuit Diagram : (i) For half deflection method (ii) For figure of merit

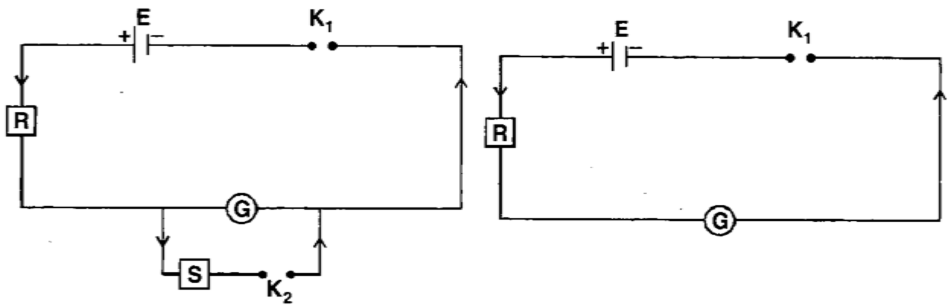


Fig. 7.1 : Resistance of galvanometer

Fig. 7.2 : Figure of merit

Formulae Used:

(i) The resistant of the given galvanometer as found by half-deflection method:

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

Where R: resistance connected in series with the galvanometer

S: shunt resistance

(ii) Figure of merit: $k = \frac{E}{(R+G)\,\theta}$

Where E : emf of the cell

θ: deflection produced with resistance R.

For Half Deflection:

S. No.	Resistance R (Ω)	Deflection in galvanometer (θ)	Shunt resistance S (Ω)	Half Deflection $\theta/2$	Galvanometer Resistance $G = \frac{RS}{R-S}\Omega$
1	4500	30	70	15	71.1
2	9500	14	70	7	70.5
3	5200	26	70	13	70.9
4	5700	24	70	12	70.8

Mean G = 70.8 Ω

Calculation: Mean G = 70.8 Ω

(i) For G : Calculate G using formula.
Take mean of all values of G recorded in table.
(ii) For k: Calculate k using formula & record in table.
Take mean of values of k.

Result:
(i) Resistance of Galvanometer by half – deflection method:
G = 70.8 Ω
(ii) Figure of merit, k = 2.19 x 10^{-5} A/div

For Figure of Merit:

S. No.	Emf of the cells E (v)	Resistance from R. B. R Ω	Deflection θ (div.)	Figure of Merit K = $\frac{E}{(R+G)\theta}$
1	1.5 x 2 = 3	4500	30	2.18 x 10^{-5}
2	3	9500	14	2.23 x 10^{-5}
3	3	5200	26	2.18 x 10^{-5}
4	3	5700	24	2.16 x 10^{-5}

Mean K = 2.19 x 10^{-5} A/div.

Precautions:
(i) All the plugs in resistance boxes should be tight.
(ii) The emf of cell or battery should be constant.
(iii) Initially a high resistance from the resistance box (R) should be introduced in the circuit. Otherwise for small resistance, an excessive current will flow through the galvanometer or ammeter & damage them.

Sources of error:
(i) Plug of the resistant boxes may not be clean.
(ii) The screws of the instruments maybe loose.
(iii) The emf of the battery may not be constant.

EXPERIMENT – 7

Aim: To convert the given galvanometer (of known resistance & figure of merit) into an ammeter of desired range & to verify the same.

Apparatus: A Weston type galvanometer whose resistance & figure of merit are given, a constantan or manganin wire, a battery, one-way key, a rheostat, a milli-ammeter, connecting wires, sand paper etc.

Circuit Diagram :

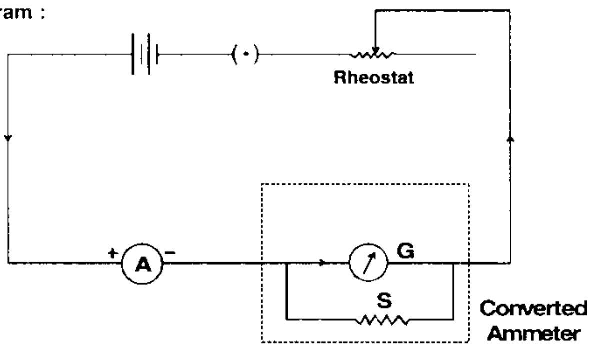


Fig. 7(A) - 1 : Converted Galvanometer into an ammeter.

Formulae Used:
To convert a galvanometer which gives full scale deflection for current I_G into an ammeter of range O to I_O amperes, the value of required shunt is given by: $S = \left(\frac{I_G}{I_o - I_G}\right)G$

Required shunt resistant S is made using a uniform wire whose, specific resistance is ρ (known) & its length:

$$l = \frac{\pi r^2 S}{\rho}$$

Observations: Given resistance of galvanometer, G = 70.8 Ω
Given value of figure of merit, k = 2.19 x 10^{-5} A div^{-1}
Total no. of divisions on either side of zero, N_o = 30
Current for full scale deflection, $I_G = N_o \times k = 6.57 \times 10^{-4}$ A

Table for Verification:

S. No.	Galvanometer Reading		Ammeter Reading $I_2 = n \times LC$	Error $(I_2 - I_1)$ A
	Deflection θ	Current $I_1 = \theta \times LC$		
1	3	3 x 0.1 = .3	6 x .05 = 0.3	0.0
2	5	0.5	11 x 0.05 = .55	0.05
3	7	0.7	15 x 0.05 = .75	0.05
4	9	0.9	19 x 0.5 = .95	0.05

a) Calculation of value of shunt resistance:
* Required range of converted ammeter, I_o = 3A
* Value of shunt resistance,

$$S = \left(\frac{I_G}{I_o - I_G}\right) \times G = 0.0155\,\Omega$$

* Computing the length of the wire to make resistance of 0.155 Ω

b) Observations for diameter of the wire:
(i) Pitch of screw gauge, p = 1 mm
(ii) No. of division of circular scale = 100
(iii) Least count, a = 0.01 mm
(iv) Zero error, e = 0.0 mm
(v) Diameter of the wire = 0.98 mm, Radius = 0.049 cm

c) Specific resistance of material of wire, $\rho = 1.92 \times 10^{-6}\ \Omega cm$

d) Required length of the wire,

$$l = S \times \frac{\pi r^2}{\rho} \quad = \frac{0.0155 \times 3.14 \times (0.049)^2}{1.72 \times 10^{-6}} \text{ cm} = 60.8 \text{ cm}$$

Verification: Checking the performance of the converted ammeter:
Current indicated by full scale deflection (N_o) of converted ammeter. I_o = 3A

Least count of converted ammeter, $k' = \frac{I_o}{N_o} = 0.1\ A/div.$

Result:

- Current I_G for full scale deflection = 6.57 x 10^{-4} A
- Resistance of shunt required to convert the galvanometer into ammeter, S = 0.0155 Ω
- Required length of wire, l = 60.8 cm
- As error $l' - l$ is very small, conversion is verified.

Precautions & Sources of Error:

(i) All connections should be neat & tight.

(ii) The diameter of the wire for making shunt resistance should be measured accurately for diameter is taken in two mutually perpendicular directions.

(iii) The terminal of the ammeter marked positive should be connected to positive pole of the battery. Also ammeter should be in series with circuit.

EXPERIMENT – 8

Aim: To find the value of *v* for different values of 'u' in case of a concave mirror & to find its focal length.

Apparatus: An optical bench with three uprights. Concave mirror, a mirror holder, two optical needles, a knitting needle & a half – meter scale.

Ray Diagram :

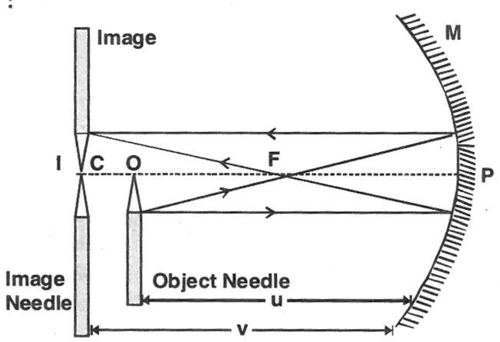


Fig. 9.1 : Focal Length of Concave Mirror

Formulae Used: The mirror formula is:

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

We have, $f = \frac{uv}{u+v}$

Where, f = focal length of concave mirror.
u = distance of object needle from pole of mirror.
v = distance of image needle from pole of mirror.

Observation:

Rough focal length of given concave mirror = 10.9 cm

Actual length of the knitting needle, x = 15 cm

Observed distance between the mirror & object needle when knitting needle is placed between them, y = 15.2 cm.

Observed distance between the mirror & image needle when knitting needle is placed between them, z = 15.8 cm.

Index error for *u*, e_1 = y – x = – 0.2 cm

Index error for *v*, e_2 = z – x = – 0.8 cm

Sr. No.	Position			Corrected Distance		1/ *u* (cm^{-1})	1/*v* (cm^{-1})
	Concave Mirror P (cm)	Object Needle O	Image Needle I	PO *u* cm	PI v cm		
1	0.0	18	26	17.8	25.2	0.056	0.037
2	0.0	17	30.3	16.8	29.5	0.06	0.034
3	0.0	16	33.4	15.8	32.6	0.063	0.031
4	0.0	26	18	25.8	17.2	0.038	0.058
5	0.0	30.3	17	30.1	16.2	0.033	0.061
6	0.0	33.4	16	33.2	15.2	0.030	0.065

Calculations:

(i) <u>$u - v$ graph:</u>

Explanation: from mirror formula applied to point A:

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

As $u = v$, $\frac{1}{f} = \frac{2}{u}$ *or* $\frac{2}{v}$ *and* $f = \frac{u}{2}$ *or* $\frac{v}{2}$

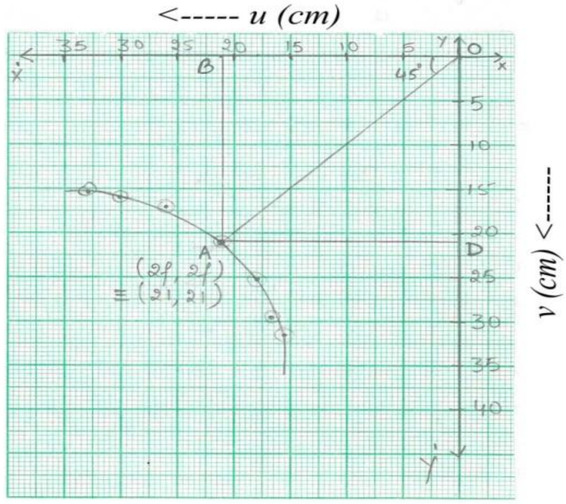
Hence, $f = \frac{-OD}{2} = \frac{-21}{2} = -10.5\,cm$

Graph Scale: X’ axis: 1 cm = 5 cm of *u*

Y’ axis: 1 cm = 5 cm of v

Also $f = \frac{-OB}{2} = -10.5cm$

<u>Mean value of *f* = -10.5 cm</u>



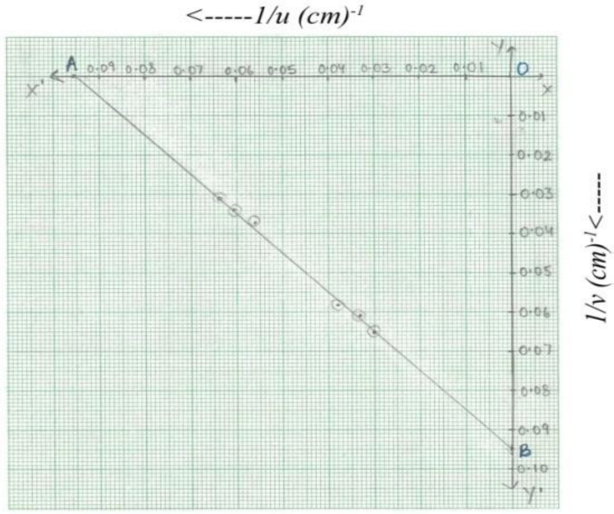
Graph between u & v

(ii) $\frac{1}{u}$ *and* $\frac{1}{v}$ *graph*:

The focal length, $f = \frac{-1}{OA} = \frac{-1}{OB} = -10.47cm$

Graph Scale: X’ axis: 1 cm = 0.01 cm^{-1} of $\frac{1}{u}$

Y’ axis: 1 cm = 0.01 cm^{-1} of $\frac{1}{v}$



Graph between 1/u and 1/v

Result: The focal length of the given concave mirror:

(i) From $u - v$ graph is : f = –10.5 cm

(ii) From $\frac{1}{u} - \frac{1}{v}$ graph is: f = –10.47 cm

Precautions:

(i) The uprights should be vertical.

(ii) Tip-to-tip parallax should be removed between the needle I and image of needle O.

(iii) To locate the position of the image the eye should be at least 30 cm away from the needle.

Sources of Error: * The uprights may not be vertical. * Parallax removal may not be perfect.

EXPERIMENT – 9

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

Apparatus: An optical bench with four uprights (2 fixed upright in middle two outer uprights with lateral movement), convex lens, convex mirror, a lens holder, a mirror holder, 2 optical needles (one thin, one thick), a knitting needle, a half meter scale.

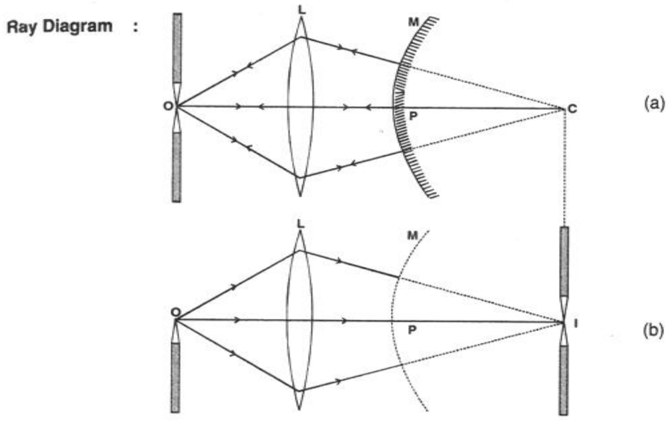


Fig. : 10.1 Focal Length of Convex Mirror

Formula Used:

Focal length of a convex mirror $f = \frac{R}{2}$

Where R is radius of curvature of the mirror.

Observation:

(i) Actual length of knitting needle, x = 15 cm.

(ii) Observed distance between image needle I and back of convex mirror, y = 15 cm

(iii) Index error = y - x = 15 – 15 = 0 cm No index correction

Observation Table:

S. N.	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

Mean R = 13.8

Calculation:

Mean corrected MI = R = 13.8 cm $f = \frac{R}{2} = 6.9\ cm$

Result:

The focal length of the given convex mirror = 6.9 cm

Precautions:

(i) The tip of the needle, centre of the mirror & centre of lens should be at the same height.

(ii) Convex lens should be of large focal length.

(iii) For one set of observations, when the parallax has been removed for convex lens alone, the position of the lens & needle uprights should not be changed.

EXPERIMENT – 10

Aim: To find the focal length of a convex lens by plotting a graph:

(i) between u and v (ii) between $\frac{1}{u}$ and $\frac{1}{v}$

Apparatus: An optical bench with three uprights, a convex lens, lens holder, two optical needles, a knitting needles & a half-metre scale.

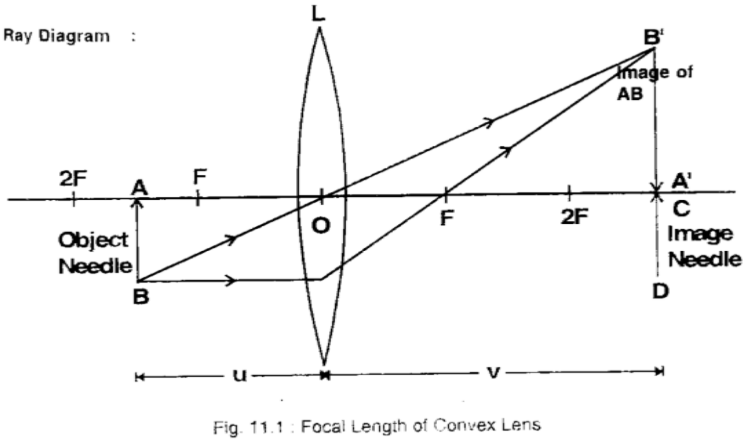


Fig. 11.1 : Focal Length of Convex Lens

Formula Used:

The relation between *u, v and f* for convex lens is:

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

Where *f:* focal length of convex lens

u: distance of object needle from lens' optical centre.

v: distance of image needle from lens' optical centre.

Observations:

(i) Rough focal length of the lens = 10 cm

(ii) Actual length of knitting needle, x = 15 cm.

(iii) Observed distance between object needle & the lens when knitting needle is placed between them, y = 15.2 cm.

(iv) Observed distance between image needle & the lens when knitting needle is placed between them, z = 14.1 cm.

(v) Index correction for the object distance u, x – y = – 0.2 cm

(vi) Index correction for the image distance v, x – z = +0.9 cm

Observation Table:

S. No.	Position of: (cm)			*u (cm)*	*v (cm)*	*1/v* (cm^{-1})	*1/u* (cm^{-1})
	Object needle	Lens	Image needle				
1	66	50	26	16	24	0.041	0.062
2	67	50	27	17	23	0.043	0.058
3	68	50	28	18	22	0.045	0.055
4	70	50	30	20	20	0.05	0.05
5	75	50	33	23	17	0.058	0.043
6	80	50	34	24	16	0.062	0.041

Calculation of focal length by graphical method:

(i) ***u – v* graph:** The graph is a rectangular hyperbola:

Scale: X' axis: 1 cm = 5 cm of *u*

Y' axis: 1 cm = 5 cm of *v*

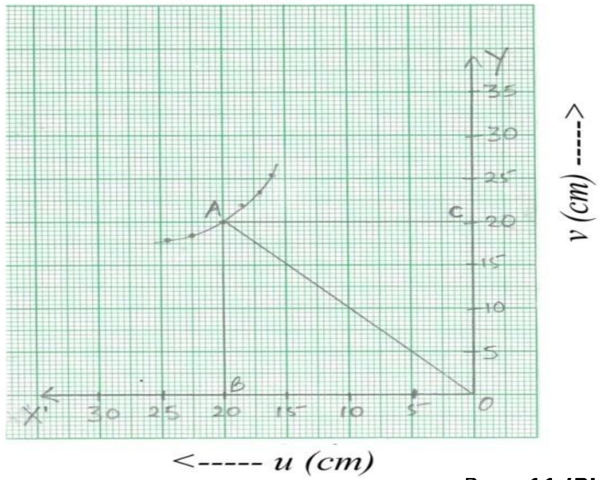
AB = AC = 2*f* or OC = OB = 2*f*

$\therefore f=\frac{OB}{2}$ *and also* $f=\frac{OC}{2}$

$\therefore$ Mean value of *f* = 10.1 cm.

(ii) $\frac{1}{u}-\frac{1}{v}$ *graph*: The graph is a straight line.

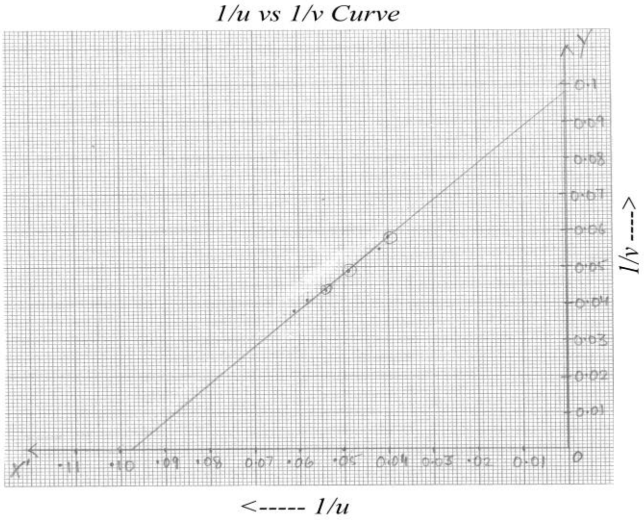
u - v curve



Scale; X' axis: 1 cm = 0.01 cm^{-1} of $\frac{1}{u}$

Y' axis: 1 cm = 0.01 cm^{-1} of $\frac{1}{v}$

Focal length, $f = \frac{1}{OP} = \frac{1}{OQ} = 10.2cm.$



Result:

(i) From *u*-*v* graph is, *f = 10.1 cm*

(ii) From $\frac{1}{u} - \frac{1}{v}$ graph is, *f = 10.2 cm*

Precautions:

(i) Tips of object & image needles should be at the same height as the centre of the lens.

(ii) Parallax should be removed from tip-to-tip by keeping eye at a distance at least 30 cm. away from the needle.

(iii) The image & the object needles should not be interchanged for different sets of observations.

EXPERIMENT – 11

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

Apparatus: An optical bench with four uprights, a convex lens (less focal length), a concave lens (more focal length), two lens holder, two optical needles, a knitting needle & a half – metre scale.

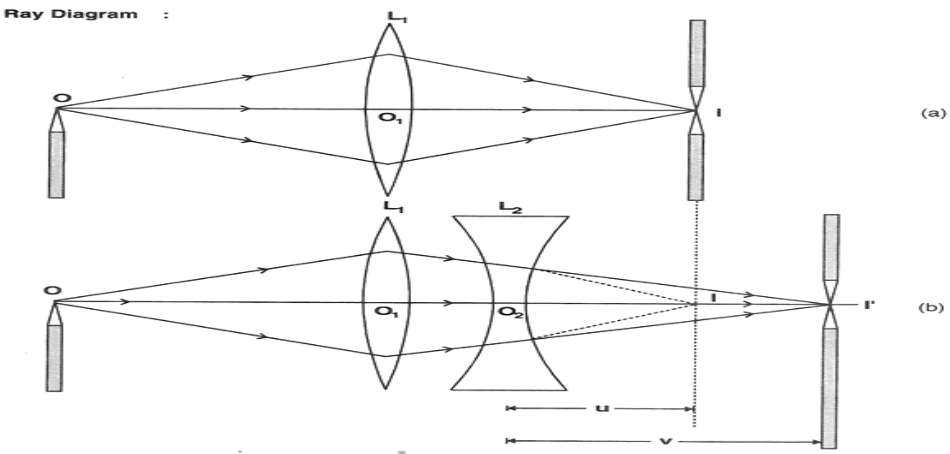


Fig. 12.1 : Focal Length of a concave lens

Formulae Used: From lens formula, we have:

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

Observations:

Actual length of knitting needle, x= 15 cm.

Observed distance between object needle & the lens when knitting needle is placed between them, y = 15 cm.

Observed distance between image needle & the lens when knitting needle is placed between them, z = 15 cm.

Index correction for u = x – y = 0 cm

Index correction for v = x – z = 0 cm

Observation Table:

S. No.	Position of (cm)					$u = IL_2$	$v = I'L_2$	$f = \frac{uv}{u-v}$
	0 (cm)	L_1 at O_1	I	L_2	I'			
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	–18.64
4	28	50	71.3	63	71.2	8.3	8.2	–17.45

Calculations:

Mean $f = \dfrac{f_1 + f_2 + f_3 + f_4}{4}$

$= -16.9$ cm ≈ -17cm.

Result: The focal length of given concave lens = – 17 cm.

Precautions:

(i) The lenses must be clean.

(ii) A bright image should be formed by lens combination.

(iii) Focal length of the convex lens should be less than the focal length of the concave lens, so that the combination is convex.

EXPERIMENT – 12

Aim: (i) To determine angle of minimum deviation for a given prism by plotting a graph between angle of incidence & angle of deviation.

(ii) To determine the refractive index of the material (glass) of the prism.

Apparatus: Drawing board, a white sheet of paper, prism, drawing pins, pencil, half metre scale, office pins, graph paper & protector.

Diagram

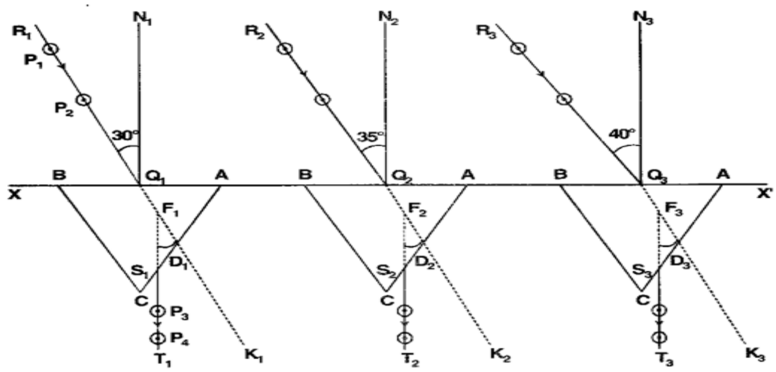


Fig. 13.1 : Refraction through prism at different angles

Formulae Used:

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

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

Where D_m is the angle of minimum deviation & A is the angle of prism.

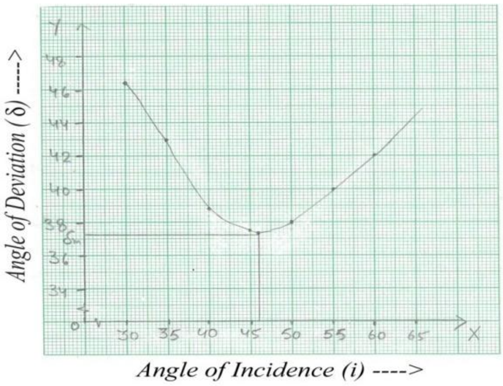
Calculations:

From graph between angle of incidence, $\angle i$ and angle of deviation, we get the value of D_m (angle of minimum deviation): $D_m = 37.8^o$

Thus, $\mu = \dfrac{\sin\left(\frac{A+Dm}{2}\right)}{\sin\left(\frac{A}{2}\right)} = \dfrac{\sin\left(97.8^o/2\right)}{\sin 30^o}$

$\mu = 1.5077$

S. No.	Angle of Incidence $\angle i$	Angle of Deviation $\angle \delta$
1	35°	43°
2	40°	38.8°
3	45°	37.8°
4	50°	38°
5	55°	40°
6	60°	42°



Result:

(i) From $\angle i - \angle D$ graph we see that as $\angle i$ increases, $\angle D$ first decreases, attains a minimum value (D_m) & then again starts increasing for further increase in $\angle i$.

(ii) Angle of minimum deviation = D_m = 37.8^o

(iii) Refraction index of material of prism, $\mu = 1.5077$

Precautions:

(i) The angle of incidence should be between $30^o - 60^o$.

(ii) The pins should be fixed vertical.

(iii) The distance between the two pins should not be less than 8 cm.

Sources of Error:

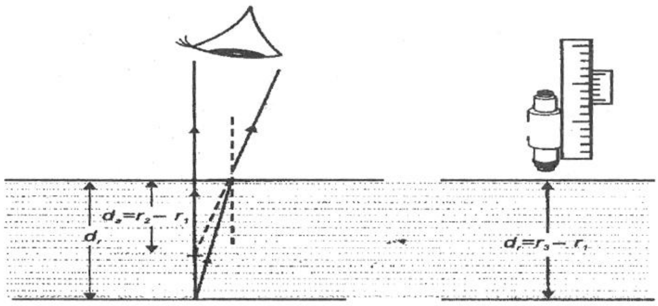
(i) Pin pricks may be thick.

(ii) Measurement of angles maybe wrong.

EXPERIMENT – 13

Aim: To determine the refractive index of a glass using travelling microscope.

Apparatus: A marker, glass slab, travelling microscope, lycopodium powder.



Formulae Used:

Refractive index $\mu = \dfrac{real\ depth}{apparent\ depth} = \dfrac{r_3 - r_1}{r_2 - r_1}$

Observations:

Least count of travelling microscope = 0.001 cm or 0.01 mm

Mean values: $r_1 = 0$ mm $r_2 = 6.81$ mm $r_3 = 10.25$ mm

Observations: Reading of Microscope focused on:

S. No.	Mark without slab $r_1 = M + n \times LC$ min	Mark with slab on it $r_2 = M + n \times LC$ min	Powder on top of slab $R_3 = M + n \times LC$ min
1	0	6.5 + 29 x 0.01 = 6.79mm	10 + 23 x 0.01 = 10.23mm
2	0	6.5 + 31 x 0.01 = 6.81mm	10 + 25 x 0.01 = 10.25mm
3	0	6.5 + 33 x 0.01 = 6.83mm	10 + 27 x 0.01 = 10.27mm

Calculations:

Real depth = $d_r = r_3 - r_1$ = Mean d_r = 10.25 mm

Apparent depth = $d_a = r_2 - r_1$

Mean d_a = 6.81 mm

$\therefore$ Refractive index, $\mu = \dfrac{real\ depth}{apparent\ depth} = \dfrac{d_r}{d_a}$ $\therefore \mu = 1.52$

Result:

The refractive index of the glass slab by using travelling microscope is determined as 1.52 = μ

Precautions:

(i) Microscope once focused on the cross mark, the focusing should not be disturbed throughout the experiment. Only rack and pinion screw should be turned to move the microscope upward.

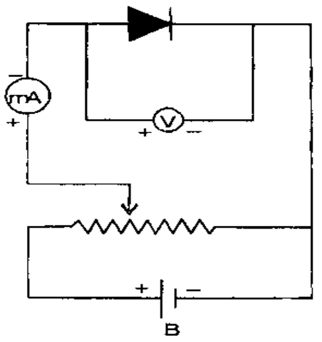
(ii) Only a thin layer of powder should be spread on top of slab.

(iii) Eye piece should be so adjusted that cross-wires are distinctly seen.

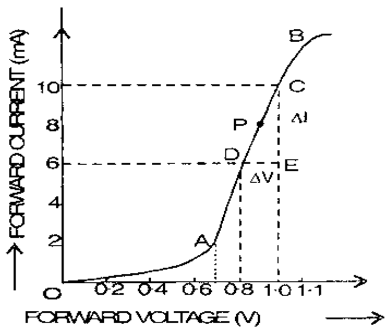
EXPERIMENT – 14

Aim: To draw the I – V characteristics curve of *p*-*n* junction in forward bias & reverse bias.

Apparatus: A *p-n* junction semi-conductor diode, a three volt battery, a high resistance, a rheostat, a voltmeter (0-3v), a milli ammeter (0-.30 mA), one – way key, connecting wires.



a



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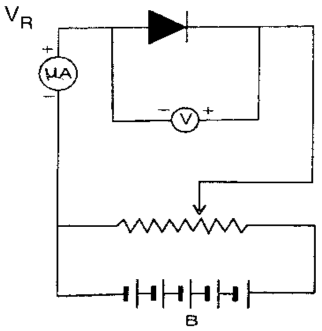
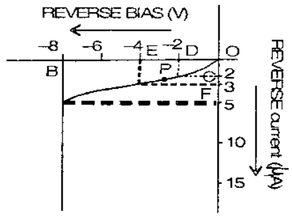


a



b

Observations:

Least count of voltmeter = 0.02 & 1 v/div Zero error = –

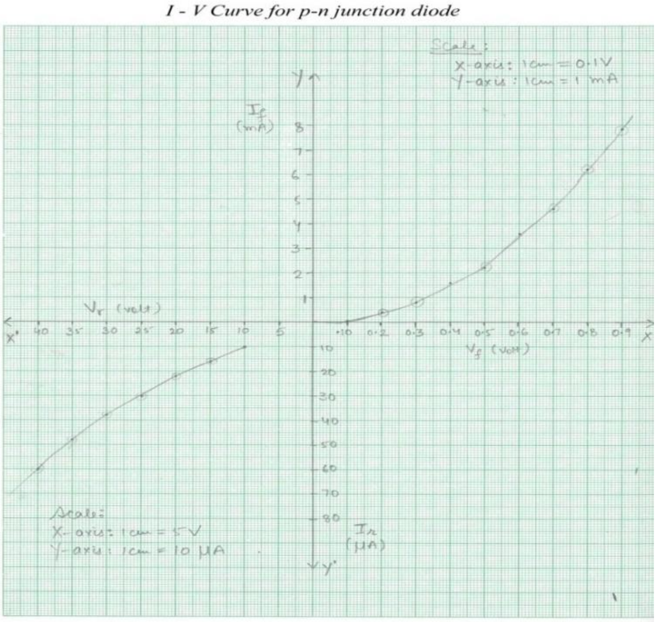
Least count of milli-ammeter = 0.2 mA/div Zero error = –

Least count of micro-ammeter = 2 μ A/div Zero error = –

Observation Table:

S. No.	Forward Bias Voltage (V)	Forward Current (mA)	Reverse bias Voltage (V)	Reverse Current (μ A)
1	10 x 0.02 = 0.20	2 x 0.2 = 0.4	10 x 1 = 10	5 x 2 = 10
2	0.30	4 x 0.2 = 0.8	15	16
3	0.40	6 x 0.2 = 1.6	20	22
4	0.50	11 x 0.2 = 2.2	25	30
5	0.60	18 x 0.2 = 3.6	30	38
6	0.70	23 x 0.2 = 4.6	35	48
7	0.80	31 x 0.2 = 6.2	40	60
8	0.90	39 x 0.2 = 7.8	45	72

I - V Curve for p-n junction diode



Calculations:

Graph is plotted between forward – bias voltage (V_F) (on x-axis) and forward current, I_F (on y – axis)

Scale: X – axis: 1 cm = V of V_F Y – axis: 1 cm = mA of I_F

Graph is plotted between reverse bias voltage, V_R (along X' axis) and reverse current, I_R (along Y' axis).

Scale: X' axis = 1 cm = V of V_R Y' axis = 1 cm = μA of I_F

Result: The obtained curves are the characteristics curves of the semi-conductor diode.

Precautions:

(i) All connections should be neat, clean & tight. (ii) Key should be used in circuit & opened when the circuit is not being used. (iii) Forward bias voltage beyond breakdown should not be applied.

Sources of error: The junction diode supplied maybe faulty.

EXPERIMENT – 15

Aim: To draw the characteristics curves of a zener diode and to determine its reverse breakdown voltage.

Apparatus: One *p-n* junction Zener diode, a power supply with potential divider (0-15V), a resistance of Ω, a micro ammeter of range (0-100 μA), a voltmeter (0-15V), connecting wires.

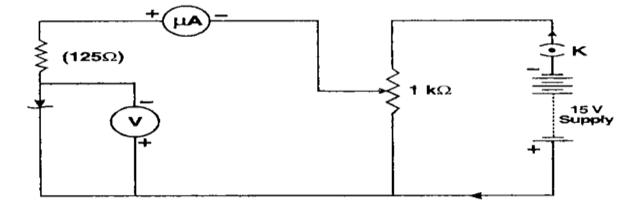


Fig 17.1 : Circuit diagram for plotting characteristic of a Zener diode

Theory:

<u>Zener diode</u>: It is a semi conductor diode; in which *n*-type & *p*-type sections are heavily doped i.e. they have more percentage of impurity atoms. It results into low value of reverse breakdown votage (V_{br}).

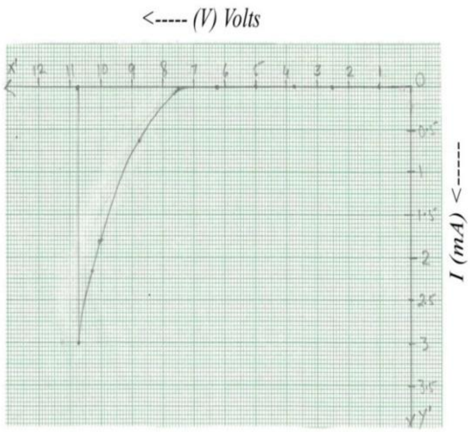
The reverse breakdown voltage of a zener diode is called zener voltage (V_z)- The reverse current that results after the breakdown is called zener current (I_Z).

Circuit Parameters:

V_I = Input (reverse bias) voltage V_o = Output voltage R_I = Input resistance, R_L = Load Resistance

Relation: $I_L = I_I - I_z$ $V_o = V_I - R_I I_I$ $V_o = R_I I_I$

S. No.	Input Voltage $V_r = n \times LC$	Input Current $I_r = n \times LC$ (mA)
1	5 x 0.25 = 1.0	0
2	10 x 0.25 = 2.5	0
3	15 x 0.25 = 3.75	0
4	20 x 0.25 = 5	0
5	25 x 0.25 = 6.25	0
6	30 x 0.25 = 7.5	0
7	35 x 0.25 = 8.75	13 x 0.05 = 0.65
8	40 x 0.25 = 10	1.8
9	41 x 0.25 = 10.25	2.25
10	43 x 0.25 = 10.75	3



Initially as V_I increases, I increases a little.

At breakdown, increase of V_I increases I_1 by large amount.

So that $V_o = V_I - R_I I_I$ = constant

This constant value of V_o is called zener voltage (V_z) or reverse breakdown voltage.

Observations: Least count of voltmeter: 0.25 v/div Least count of milli ammeter: 0.05mA/div

Result: From the graph of I_r vs V_r, the reverse breakdown voltage for the zener diode is 10.75V

Precautions: (i) The Zener diode p-n junction should be connected in reverse-bias i.e. p-terminal to –ve and to positive terminal of battery. (ii) Zero error in the instruments should be adjusted in readings.

(iii) Voltmeter & ammeter of appropriate least counts should be used.

NOTE: Activity file with SIX Activities
(A-3, A-4, A-6 and B-8, B-11, B-12) Physics Practical File) and ONE Project Report has to be made by each student from the Manual.

Activity 3

Object : To assemble a household circuit, comprising three bulbs, three (on / off) switches, a fuse and power source.

Apparatus : Three bulbs (20 W, 50 W & 100 W), three (On / Off) switches, flexible connecting wire with red and black plastic covering, a fuse wire, a two pin plug, main electric board with two pin socket and main switch.

Diagram :

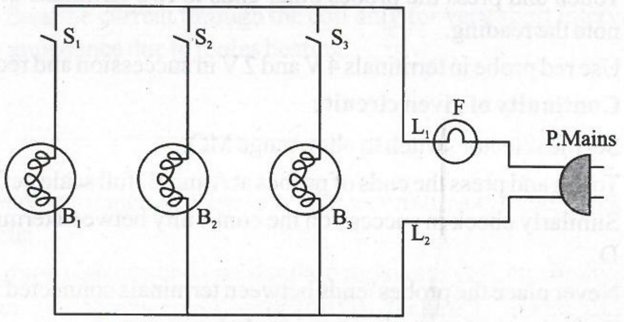


Fig. 3.1 : 3 bulb circuit

Theory : Household circuit functions on main suply 220 V, 50 Hz and current rattings of 5A for domestic supply for normal appliances, bulbs fluorescent tubes, fans etc.

Power supply : 15 A for heavy load appliances, refrigerator, air conditioner, geuser hot plates etc.

Total power consumption 'P' at any time,

$$P = P_1 + P_2 + P_3 + ...$$

where P_1, P_2, P_3 .... are powers drawn by appliances

At a potential 'V', the current I drawn from the mains is

$$P = VI \quad \text{i.e. } I = \frac{P}{V}$$

for P in watt and V in volt, I will be in amperes.

Normally, to protect the appliances from damage when unduly high currents are drawn, fuse of a little higher rating, 10 to 20% higher than the current normally drawn are connected in series with set of appliances.

Remember that in household circuits, all appliances are connected in PARALLEL with a switch connected in series with each appliance in supply LIVE line.

Also for further safety, a suitable value MAINS FUSE is connected in series with supply source. Note that fuse is a safety device, never use a fuse of much higher rating than the one recommended.

Procedure :

(i) Connect one end of the bulb holder to the red flexible wire through a switch S in series. Connect the other end of the bulb holder to the black flexible wire.

(ii) Connect the three bulb switch combination in parallel, red wire ends at one point and the black wire end at the other point.

(iii) Take two long flexible wires to serve as lead wire, one wire is red and the other is black.

(iv) Connect the red wire end to the red wire L_1. It will serve as a live lead.

(v) Connect the black wire ends to the black wire L_2. It will serve as neutral lead.

(vi) Put the fuse wire F in live lead L_1.

(vii) Connect a plug (two pin plug) P at the end of the two leads.,

(viii) Insert the plug in a two pin socket provided in the main electric board (inserting the upper pin for L_1 in upper hole of the socket and the lower ping for L_2 in lower hole of the socket).

Testing : Make the switches on one by one. Then put them off one by one.

Observation : The bulbs glow when the switch is made on. It stops glowing when the switch is put off.

Activity 4

Object : To assemble the components of a given electrical circuit (say Ohm's law circuit)

Apparatus : A voltmeter and an ammeter of appropriate range, a battery, a rheostat, one way key, an unknown resistance coil, connecting wires, a piece of sand paper.

Diagram :

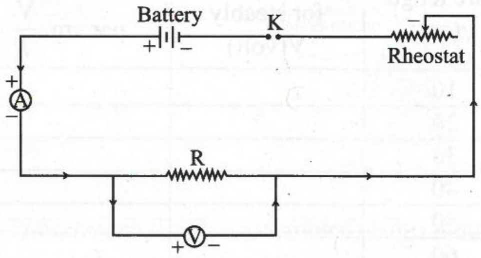


Fig. 4.1 : Circuit Diagram

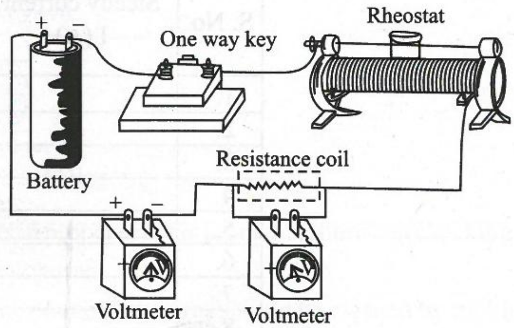


Fig. 4.2 : Arrangement Diagram

Procedure :

(i) Connect the items as shown in Fig. 4.2

(ii) For measuring current, ammeter should be connected in series with the components.

(iii) For measuring potential drop, voltmeter should be connected in parallel with the resistance coil or wire.

Conclusion : Assembly of all the components in electric circuit is complate.

Activity 6

Object : To draw a diagram of a given open circuit comprising of least a battery, resistor, rheostat, key, ammeter and voltmeter. Mark the components that are not connected in proper order and correct the circuit and also the circuit diagram.

Apparatus : A voltmeter and an ammeter of appropriate range, a battery, a rheostat, one way key, unknown resistance wire or resistance coil, connecting wires, a piece of sand paper

Diagram : An open circuit (not connected circuit) is given:

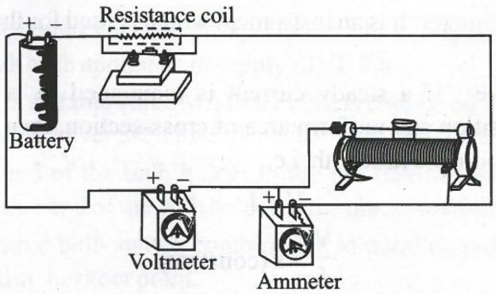


Fig. 6.1 : Open Circuit Diagram (Components not connected in proper order).

Theory :

(a) **Functional electrical circuit:** A circuit is functional only when all the components of the circuit are connected in proper order, assuming that all circuit components are in working condition and key is closed.

(b) **Open electrical circuit :** An open circuit means that there is a break in some part of the circuit. The break may be deliberate suchas key is in open position or three is a fault such as broken wire or burnt or loose connection.

Procedure :

(1) Draw the circuit 6.1 in copy.

(2) Write various components & mark those which are not connected in proper order.

(3) Draw the correct circuit diagram.

(4) Now close the key and check up whether the corrected circuit is now functional.

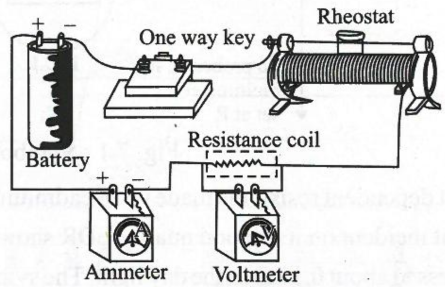


Fig. 6.2 : Arrangement Diagram

Result : The connected circuit assembled using components in proper order is found functional on checking.

Precautions :

(1) Range of Voltmeter and Ammeter should be chosen.

(2) Before making connections, the ends of the connecting wires should be cleaned by rubbing with (sand paper).

Activity 8

Aim : To identify a diode, an LED, a transistor, an IC, a resistor and a capacitor from a mixed collection of such items.

Apparatus : Multimeter, Battery, eliminator, reversing key, above mixed collection of items.

Diagram :

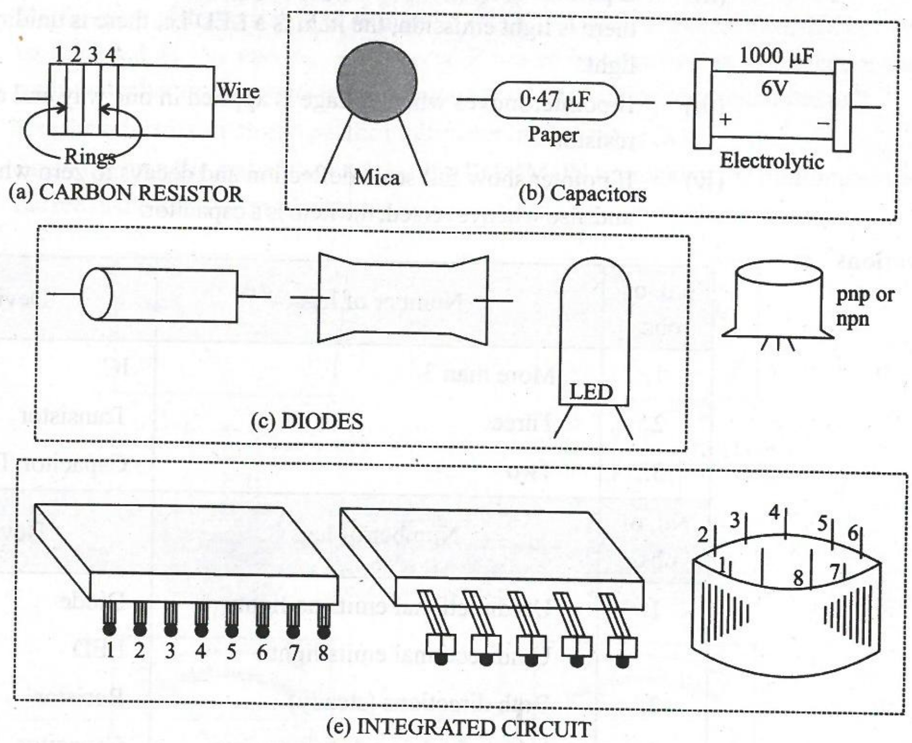


Fig. 8.1 : Some of the commonly available electronic components.

Theory : For identification, appearance and working of each item will have to be considered

(i) A diode is a two terminal device. It conducts when forward biased and does not conduct when reverse biased. It does not emit light while conducting.

(ii) A LED (light emitting diode) is also a two terminal device. It also conducts when forward biased and does not conduct when reverse biased. It emits light while conducting.

(iii) A transistor is a three terminal device. The terminals represent emitter (E), base (B) and collector (C)

(iv) An IC (integrated circuit) is a multi terminal device in form of a clip.

(v) A resistor is a two terminal device. It conducts when either forward biased or reverse biased (In fact there is no forward or reverse bias for a resistor). It conducts even when operated with A.C. voltage.

(vi) A capacitor is also a two terminal device. It does not conduct when either forward biased or reverse biased (Hence it does not conduct with D.C. voltage) However it conducts with A.C. voltage.

Procedure :

(i) If the item has four or more terminals and has from of a chip, it is an IC (Integrated circuit).

(ii) If the item has three terminals, it is transistor.

(iii) If the item has two terminals, it may be diode, a LED, a resistor or a capacitor.

To differentiate proceed as ahead :

Make a series circuit with battery eliminator, reversing key, the item and the multimeter with range set in milliamperes. Switch on the battery eliminator and watch the movement of the multimeter pointer.

(i) If pointer moves when voltage is applied in one way and does not move when reversed and there is no light emission, the item is diode i.e. there is only unidirectional flow of curent and emits no light.

(ii) If pointer moves when voltage is applied in one way and does not move when reversed and there is light emission, the item is a LED i.e. there is unidirectional flow of current & emits light.

(iii) If pointer moves when voltage is applied in one way and also when reversed, the item is a resistor.

(iv) If pointer show full scale deflection and decays to zero when voltage is applied in one way and also when reversed, the item is a capacitor.

Observations :

No. of obs.	Number of legs	Device
1.	More than 3	IC
2.	Three	Transistor
3.	Two	Capacitor, Diode or resistor

No. of obs.	Number of legs	Device
1.	Unidirectional emits no light	Diode
	Unidirectional emits light	LED
2.	Both directions (steady)	Resistor
3.	Initialy high but decays to zero	Capacitor

Activity 11

Object : To observe the polarisation of light using two polaroids.

Apparatus : Two polaroid pieces, a source of light (say, an electric bulb, or sunlight).

Diagram :

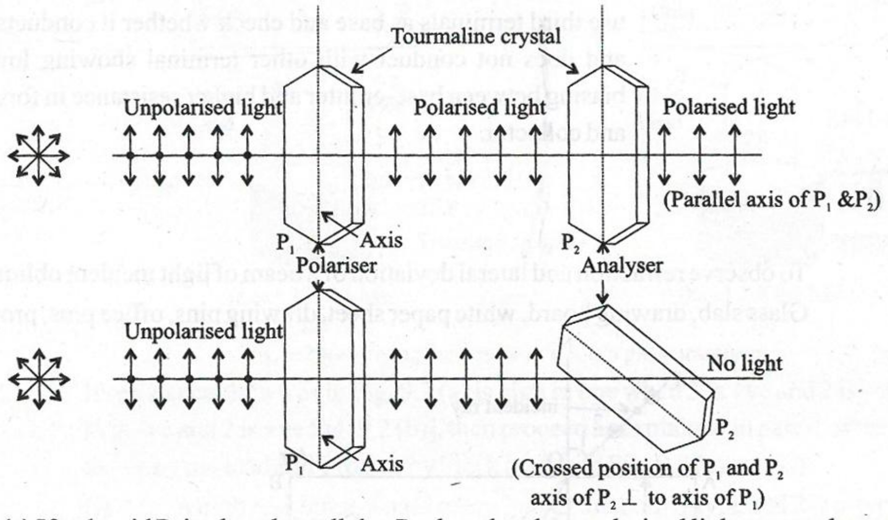


Fig. 11.1 : (a) If polaroid P_2 is placed parallel to P_1, then the plane polarised light passes through P_2 also.
(b) No light passes if the two polaroids are crossed i.e. axis of P_2 is perpendicular to that of P_1.

Theory : If another polaroid piece is placed in the path of the plane polarised light so that the two polaroid pieces are in cross position (i.e., axes of the two polaroid pieces are perpendicular to each other) then no light will come out of the second polaroid piece. If the axes of the two polaroids are parallel to each other then the polarised light produced by the first polaroid is able to pass through the second polaroid. The second polaroid P_2 is called analyser and the first polaroid P_1 is called polariser.

Procedure & Observation :

(i) Take the polaroid piece P_1 and look towards the lighted bulb in your room through it. You are able to see the lighted bulb with decreased intensity.

(ii) Now take the other polaroid piece P_2 and put it over the first polaroid P_1 and now look at the lighted bulb through the combined system and rotate one polaroid with respect to the other and observe what happens.

You will find that :

(i) In one position [Fig. 11.1 (a)] when the axis of two polaroids P_1 and P_2 are parallel to each other, the bulb is seen maximum bright.

(ii) In another position [Fig. 11.1 (b)] when the axis of polaroid P_2 is perpendicular to axis of polaroid P_1, no light is seen.

Conclusion : The above activity shows that polaroid pieces produce plane (or linearly polarised light). This polarised light does not pass through another polaroid when it is placed crossed with (i.e. at 90°) respect to the first polaroid.

Activity 12

Object : To observe diffraction of light due to a thin slit between sharp edges of razor blades.

Apparatus : Microscope slides (two), two razor blades, adhesive tapes, a screen and source of monochromatic light (laser pencil), black paper.

Theory : When light is allowed to pass through fine openings or around sharp obstacles like edge of razor blades such that size of opening or sharpness of edges is of the order of wavelength of light, it bends around corners. Bending of light around sharp obstacles or corners is termed as diffraction. The angle of diffraction for different orders (n) of diffraction is given as

$$d \sin\theta = n\lambda$$

Diagram :

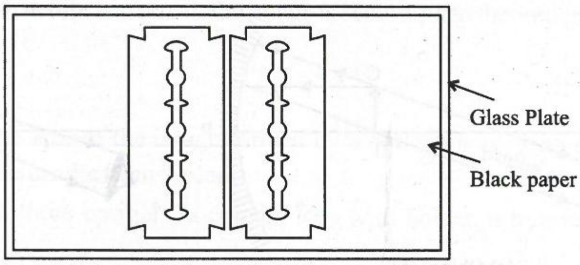


Fig. 12.1A thin slit made by using two razor blades, black paper and glass plate.

Procedure :

(i) Making of fine slit using razor blades.

(ii) Place two razor blades with their sharp edges facing each other and extremely close to each other such that there is small gap of the order of fraction of millimeter. Fig. 12.1

(iii) Paste the blades using cello-tape leaving no gap between paper and glass plate.

(iv) Cut the small slit in between the sharp edges of blades.

(v) Place the slit about 0.5 m from a wall and a source of light with a slit in front of it at a distance of about 20 cm from the slit.

(vi) Observe the light falling on the wall.

(vii) It will be observed that instead of having a bright slit like light on the wall, the light spreads and on either side of slit secondary maxima i.e. slits with lower intensity are seen.

Conclusion : When light waves are made to be incident on very fine openings (slit) they bend and spread showing the phenomena of diffraction of light.

Precautions :

(i) Black paper should be pasted such that there is no air gap between the glass plate and paper.

(ii) The slit should be made as thin as possible.

(iii) Instead of using ordinary electric bulb light, laser torch light will give better effect on the screen.