

## EXPERIMENT 2

**Finding the resistance of a given wire using meter bridge and hence determine resistivity of its material:**

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

**Apparatus:**

A meter bridge (slide wire bridge) , a leclanche cell, a galvanometer , a resistor , a jockey , a one way key , a resistance wire , a screw gauge , a meter scale , a set of square , connecting wire , a piece of sand paper.

**Theory:**

The unknown resistance 'X' is given by

$$X = \left( \frac{100-L}{L} \right) R$$

1. Where 'R' is the known resistance placed in the left gap & unknown resistance 'X' is the right gap of Meter Bridge. 'L' is length of meter bridge wire from zero end up to balance.
2. Resistivity of the material of the given wire is given by

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

Where 'L' is the length & D is the diameter of the given wire.

### Procedure:

1. Arrange the apparatus as shown in the arrangement diagram.
2. Connect the resistance wire whose resistance is to be determined in the right gap b/w C & B. Take care that no point / part of the wire forms a loop.
3. Connect resistance box of low range in the left gap b/w A & B.
4. Make all other connections as shown in the circuit diagram.
5. Take out some resistance from the resistance box, press the key 'K'.
6. Touch the jockey gently first at length end & then right end of the bridge wire.
7. Note the deflection in the galvanometer. If the galvanometer shows deflection in the opposite direction the corrections are correct. If the deflection is on one side only then there is a fault in the circuit. Check & rectify the fault.
8. Move the jockey gently along the wire from left to right till it gives zero deflection. The point where the jockey is touching the wire is the null point 'D'.
9. Choose an appropriate value of 'R' from the box such that there is no deflection in the galvanometer when the jockey is nearly in the middle of the wire.
10. Note the position of point 'D' to know the length  $AD=l$ .
11. Take at least 4 sets of observations in the same way by changing the value of R in the steps.
12. Record your observations.

### 13. For specific resistance

1. Cut the resistance wire at the point where it leaves the terminal, straighten it & find its length by using a meter scale.
2. Measure the diameter of the wire at least at 4 places in two mutually perpendicular directions at each place with the help of a screw gauge.
3. Record your observations as given in the table.

**Observation:**

1. Length of a given wire  $L = 66 \text{ cm} = 0.66 \text{ m}$
2. Table for unknown resistance (X)

| Resistance from box, R<br>(Ohm) | Length AB = l<br>(cm) | Length BC = (100-l)<br>(cm) | <u>Unkown</u><br>Resistance<br>$X = [R(100-l)]/L$<br>(ohm) |
|---------------------------------|-----------------------|-----------------------------|--|
| 0.5                             | 58.3                  | 41.7                        | 0.35   |
| 0.7                             | 60.7                  | 39.3                        | 0.45   |
| 1                               | 61.9                  | 38.1                        | 0.61   |
| 1.5                             | 61.1                  | 38.9                        | 0.95   |
|                                 |                       |                             | Mean = 0.59  |

**Result:**

1. The value of the unknown resistance  $X = 0.5 \text{ ohm}$
2. The specific resistance of material of wire =  $0.104 \times 10^{-3} \text{ ohm m}$
3. Percentage error

**Precaution:**

The connection should be neat, clean & tight.

### EXPERIMENT 3

**Verifying laws of combination (parallel) of resistance using meter bridge:**

**Aim:** To verify laws of combination (parallel) of resistance using meter bridge.

**Apparatus:** a meter bridge , a leclanche cell , a galvanometer , a jockey , a jockey , a resistance box , two resistance wire , connecting wires , set square .

**Theory:**

The resistance ( $r$ ) of a resistance wire or coil is given by  $r = (100-l)/L * R$  where  $R$  is the resistance from resistance box in the left gap and  $L$  is the length of meter bridge wire from  $O$  end upto balance point.

When  $r_1$  and  $r_2$  are connected in parallel, then their combined resistance

$$R_p = r_1 r_2 / r_1 + r_2$$

**Procedure:**

1. Mark the two resistance wires as  $r_1$  and  $r_2$
2. Connect the two coils  $r_1$  and  $r_2$  in parallel as shown in fig. in the right gap of Meter Bridge and find the resistance of this combination. Take at least three set of observation
3. Record your observation.

**Value of  $r_1$ :**

| Resistance of R.B. (ohm) | Balance L (cm) | (100-l) (cm) | $[(100-l)*R]/L$ | Mean $r_1$ |
|--------------------------|----------------|--------------|-----------------|------------|
| 0.5                      | 59             | 41           | 0.347           | 0.6393     |
| 1                        | 37             | 63           | 0.587           |            |
| 2                        | 33             | 67           | 0.985           |            |

**Value of  $r_2$ :**

| Resistance of R.B. (ohm) | Balance L (cm) | (100-l) (cm) | $[(100-l)*R]/L$ | Mean $r_2$ |
|--------------------------|----------------|--------------|-----------------|------------|
| 0.5                      | 83.2           | 16.8         | 0.1009          | 1.729      |
| 1                        | 80.8           | 19.2         | 4.208           |            |
| 2                        | 69.4           | 30.6         | 0.881           |            |

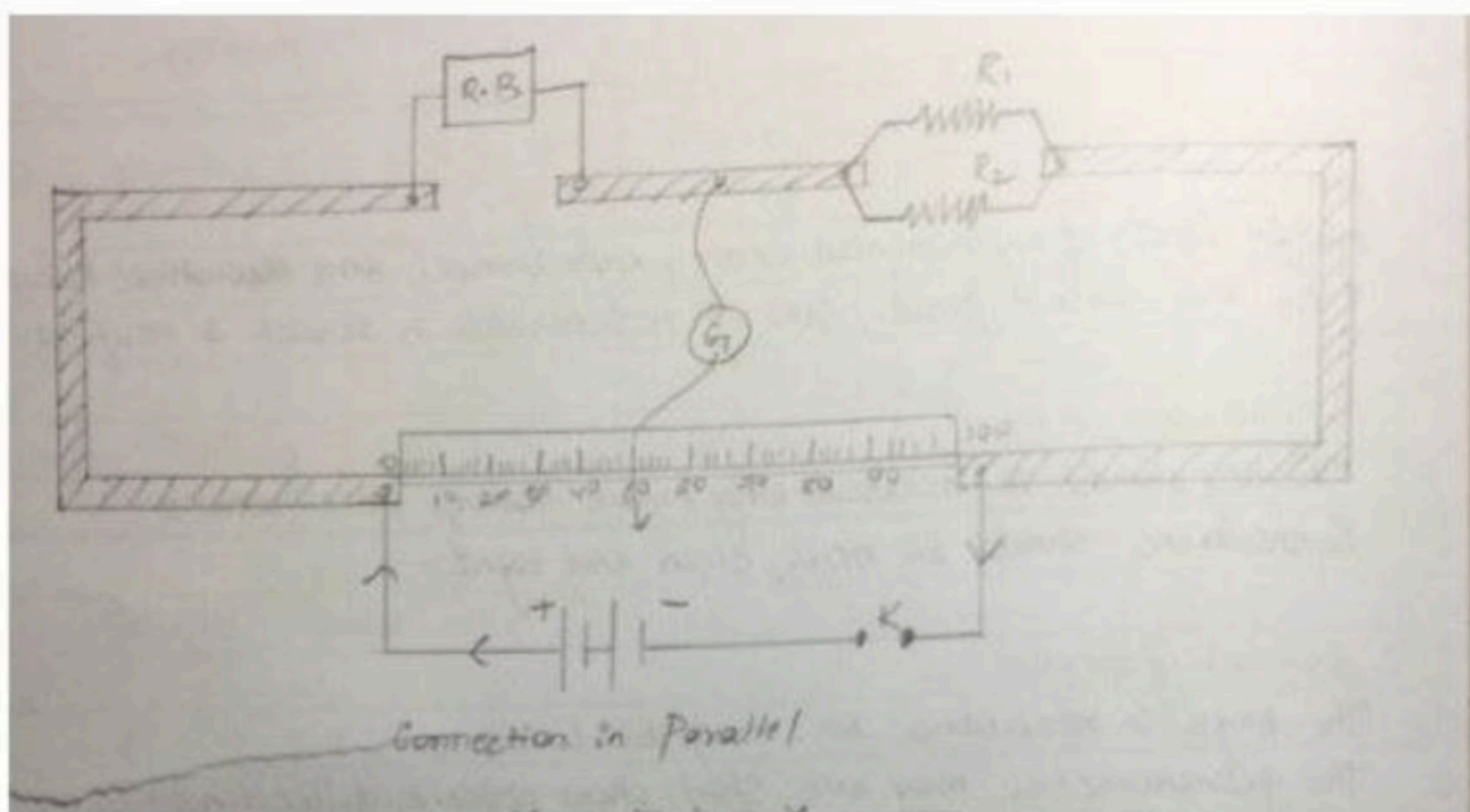
**Value of  $r_p$ :**

| Resistance of R.B. (ohm) | Balance L (cm) | (100-l) (cm) | $[(100-l)*R]/L$ | Mean $r_p$ |
|--------------------------|----------------|--------------|-----------------|------------|
| 0.1                      | 27             | 73           | 0.27            | 0.36       |
| 0.2                      | 32             | 68           | 0.42            |            |
| 0.5                      | 56             | 44           | 0.39            |            |

**Calculations:**

$$R_p = (R_1 R_2) / (R_1 + R_2) = (0.693 \times 1.729) / (0.693 + 1.729) = 0.4667 \text{ ohm}$$

$$\text{Experimental Error} = [(0.36 - 0.4667) / (0.36)] * 100 = 29.6\%$$



**Result:**

Within limit of experimental error, experimental and theoretical values of  $R_p$  are same. Hence law of resistance in parallel are verified.

**Precaution:**

The key should be inserted only while taking observation.

Connection should be neat and tight.

## EXPERIMENT 1

~~Determining resistance per cm of given wire by plotting a graph of potential difference versus current.~~

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

### APPARATUS REQUIRED:

Battery, key, rheostat, voltmeter, ammeter, resistance wire (unknown resistance), connecting wires, meter scale, sandpaper.

### PRINCIPLE:

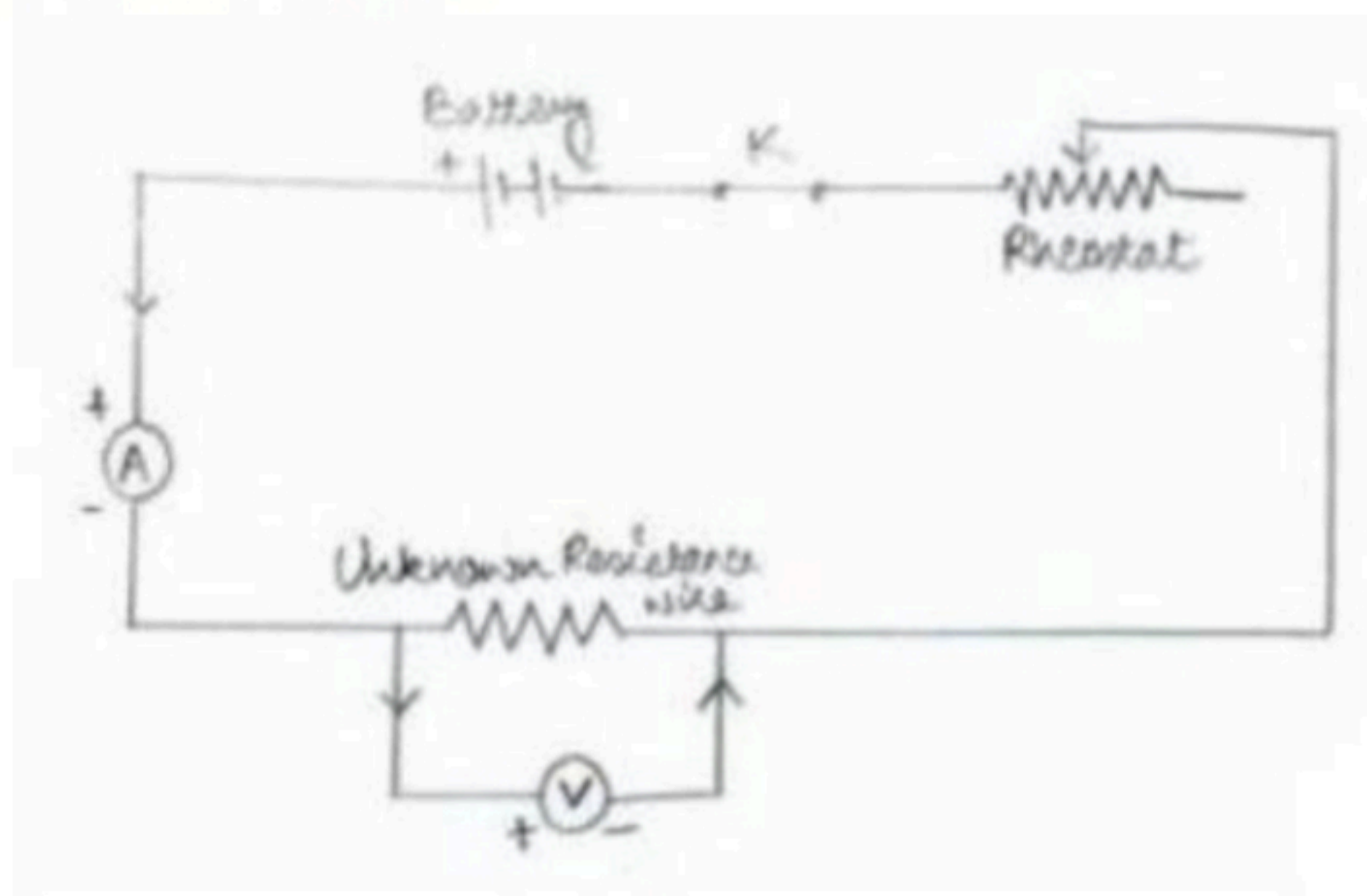
This Experiment is based on OHM'S LAW

Ohm's Law states that the electric current passing through a conductor is directly proportional to the potential difference applied across its ends.

Mathematically,  $V=IR$

The resistance  $R$  of the wire depends on the material of the wire and its dimensions.

### CIRCUIT DIAGRAM:



### PROCEDURE:

1. Draw the circuit diagram as shown in figure above
2. Arrange the apparatus as per the circuit diagram
3. Clean the ends of the connecting wires with sandpaper and make them shiny.
4. Make the connections as per circuit diagram. All connections must be neat and tight. Take care to connect the ammeter and voltmeter with their correct polarity. (+ve to + and -ve to -ve)
5. Determine the zero error and least count of the ammeter and voltmeter and record them.

6. Adjust the rheostat to pass a low current.
7. Insert the key K and slide the rheostat contact to see whether the ammeter and voltmeter are showing deflections properly.
8. Adjust the rheostat to get a small deflection in ammeter and voltmeter.
9. Record the readings of the ammeter and voltmeter
10. Take at least six sets of readings by adjusting the rheostat gradually
11. Plot a graph with V along X axis and I along axis.
12. The graph will be a straight line which verifies Ohm's law
13. Determine the slope of the V-I graph. The reciprocal of the slope gives the resistance the wire.

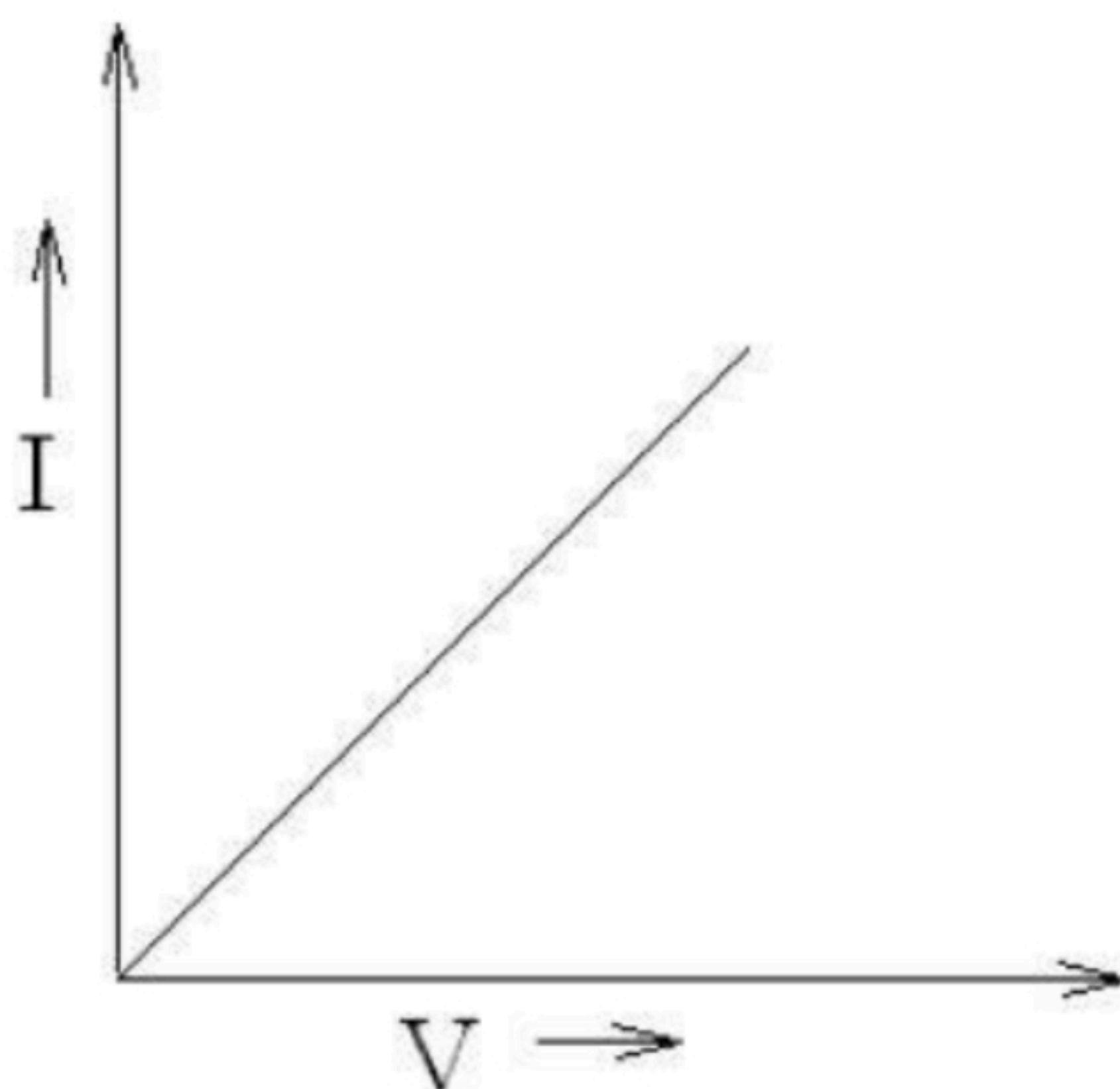
### **OBSERVATIONS:**

1. Range  
Range of the given Ammeter = 0-500m A  
Range of the given voltmeter = 0-5V
2. Least Count  
Least Count of the given Ammeter = 10Ma  
Least Count of the given voltmeter = 0.1V
3. Zero Error  
Zero Error of the given Ammeter = 0A  
Zero Error of the given voltmeter = 0V
4. Zero Correction  
Zero Correction of the given Ammeter = 0A  
Zero Correction of the given voltmeter = 0V

5. Observation Table for Ammeter and Voltmeter Readings.

| S No | Ammeter Observed (A) | Ammeter Corrected (A) | Voltmeter Observed (V) | Voltmeter Corrected (V) |
|------|----------------------|-----------------------|------------------------|-------------------------|
| 1    | 0.3                  | 0.3                   | 0.1                    | 0.1                     |
| 2    | 0.7                  | 0.7                   | 0.2                    | 0.2                     |
| 3    | 1.1                  | 1.1                   | 0.3                    | 0.3                     |
| 4    | 1.5                  | 1.5                   | 0.4                    | 0.4                     |
| 5    | 1.9                  | 1.9                   | 0.5                    | 0.5                     |

Graph



Voltage v/s Current Graph

**CALCULATIONS:**

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

Length of resistance wire = 40.2cm

Value of slope of  $VI$  graph =  $0.27\Omega$

Resistance per unit length =  $0.675\Omega\text{m}^{-1}$

**RESULT:**

1. Ohm's Law is verified as the  $I$  vs  $V$  graph is a straight line
2. The resistance of the given wire =  $0.28\Omega$
3. The resistance per cm of given wire is  $0.675\Omega\text{m}^{-1}$ .

**PRECAUTIONS:**

1. All the electrical connections must be neat and tight.
2. Voltmeter and Ammeter must of proper range
3. The key should be inserted only while taking readings.

#### EXPERIMENT 4

**To verify the laws of combination (series) of resistance using a meter bridge ( $R=R_1 + R_2$ ):**

**Aim:** To verify the laws of combination (series) of resistance using a meter bridge ( $R=R_1 + R_2$ )

**Apparatus :** a meter bridge , a leclanche cell (battery eliminator ) , a galvanometer , a resistance box , a jockey , two resistance wire or two resistance coils , set square , connecting wires .

**Theory:**

1. The resistance ( $r$ ) of a wire or coil is given by

$$r = \frac{(100-l) \cdot R}{l}$$

Where  $R$  is the resistance from resistance box in the left gap and  $l$  is the length of the meter bridge wire from zero end up to balance point.

2. When two resistance  $r_1$  &  $r_2$  are connected in series, then their combined resistance

$$R_3 = R_1 + R_2$$

**Procedure:**

1. Mark the two resistance coil as  $r_1$  and  $r_2$ .
2. To find the  $r_1$  and  $r_2$  proceed same way as in experiment 1.

(If  $r_1$  and  $r_2$  are not known)

1. Connect the two coils  $r_1$  and  $r_2$  in series as shown circuit diagram in the right gap of Meter Bridge and find the resistance of this combination. Take at least three sets of observation.
2. Record your observation.

**Observation table:**

| Resistance in R.B. (ohm) | Balance l (cm) | (100-l) (cm) | $[(100-l)*R]/l$ | Mean $r_1$ (cm) |
|--------------------------|----------------|--------------|-----------------|-----------------|
| 0.5                      | 24             | 76           | 1.583           | 1.616           |
| 1                        | 38             | 62           | 1.631           |                 |
| 2                        | 55             | 45           | 1.636           |                 |

| Resistance in R.B. (ohm) | Balance l (cm) | (100-l) (cm) | $[(100-l)*R]/l$ | Mean $r_2$ (cm) |
|--------------------------|----------------|--------------|-----------------|-----------------|
| 0.5                      | 33             | 67           | 1.015           | 1.015           |
| 1                        | 50             | 50           | 1               |                 |
| 2                        | 66             | 34           | 1.030           |                 |

| Resistance in R.B. (ohm) | Balance l (cm) | (100-l) (cm) | $[(100-l)*R]/l$ | Mean $r_s$ (cm) |
|--------------------------|----------------|--------------|-----------------|-----------------|
| 0.5                      | 16             | 84           | 2.625           | 2.615           |
| 1                        | 28             | 72           | 2.571           |                 |
| 2                        | 43             | 57           | 2.651           |                 |

**Calculation:**

$$R_1 + R_2 = 1.616 + 1.015 = 2.631 \text{ ohm}$$

$$R_s = 2.615 \text{ ohm}$$

$$\text{Therefore, experimental error} = [(2.615 - 2.631) / 2.615] * 100 = 0.6\%$$

**Result:**

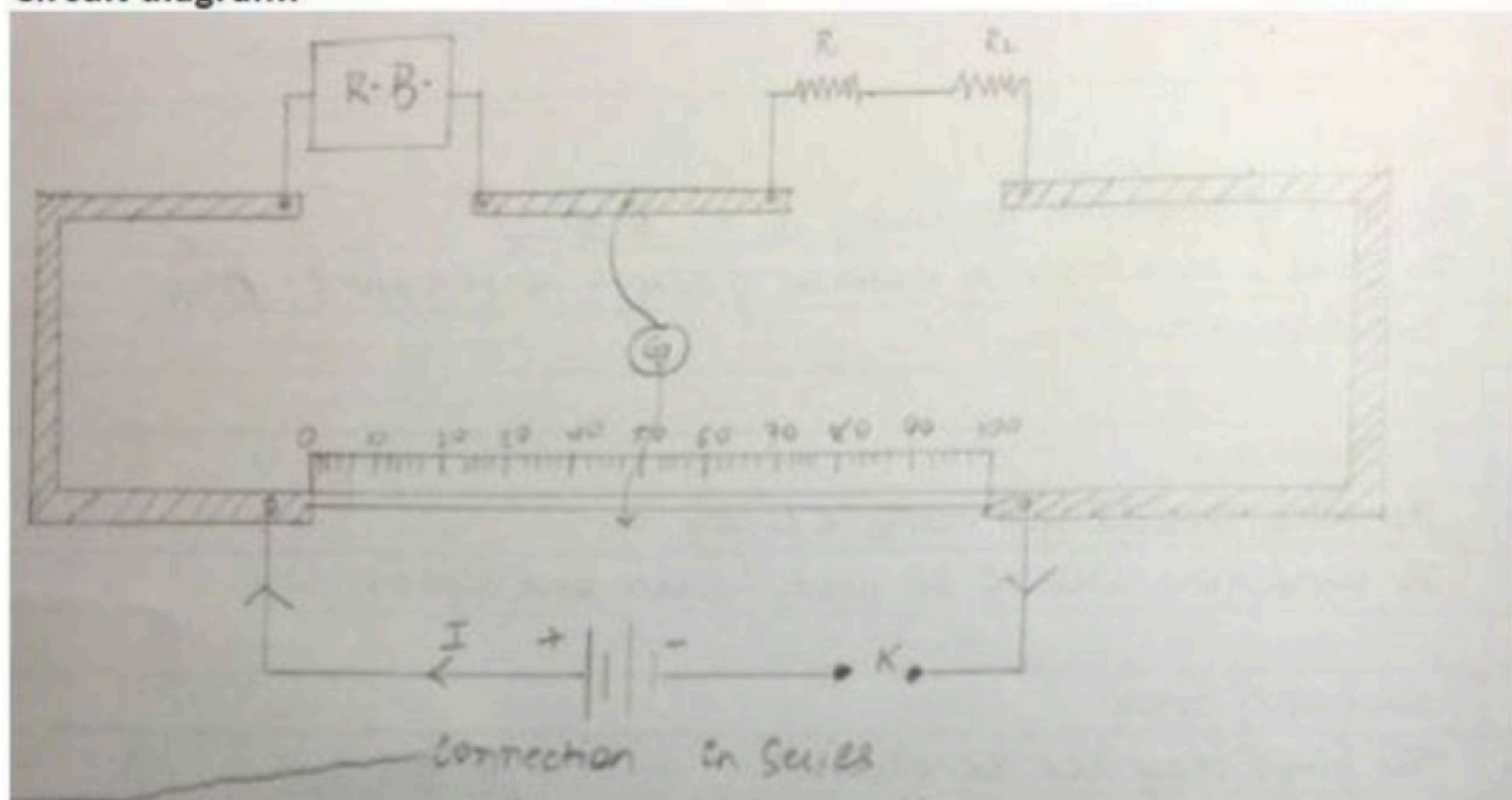
Within limits of experimental error, experimental and theoretical values of R are same. Hence law of resistance in series is verified.

**Precaution:**

1. The key should be inserted only while taking observation.
2. Connections should be neat and tight.

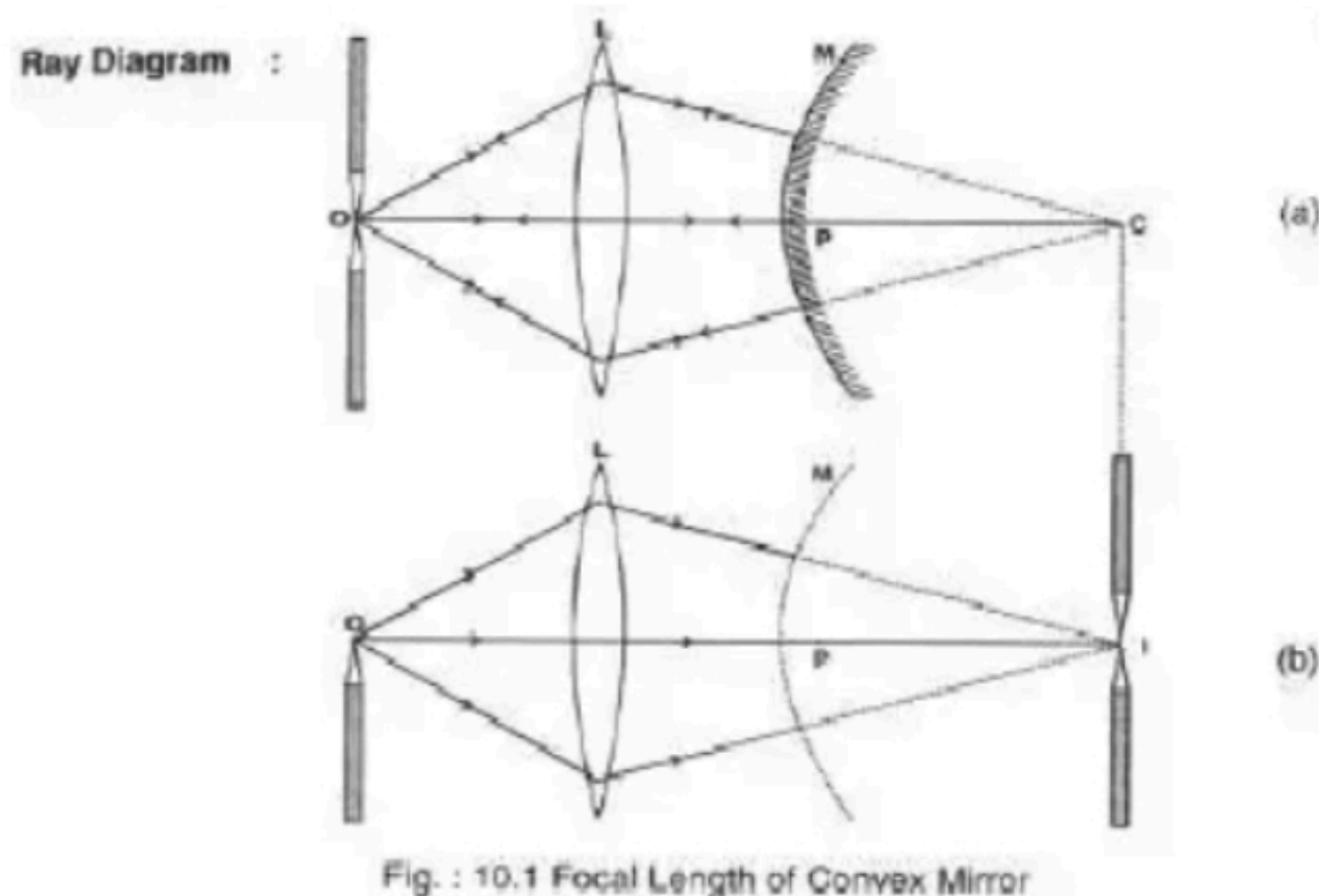


Circuit diagram:



**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, half meter scale.



**Formula Use d:**

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

Where R is radius of curvature of the mirror.

**Observation:**

- (i) Actual length of knitting needle,  $x = 15 \text{ cm}$ .
- (ii) Observed distance between image needle I and back of convex mirror,  $y = 15 \text{ cm}$
- (iii) Index error =  $y - x = 15 - 15 = 0 \text{ cm}$  No index correction

**Observation Table:**

| S. N. | Position of:         |           |             |                     | Radius of Curvature MI (cm) |
|-------|----------------------|-----------|-------------|---------------------|-----------------------------|
|       | Object needle O (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

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

**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.

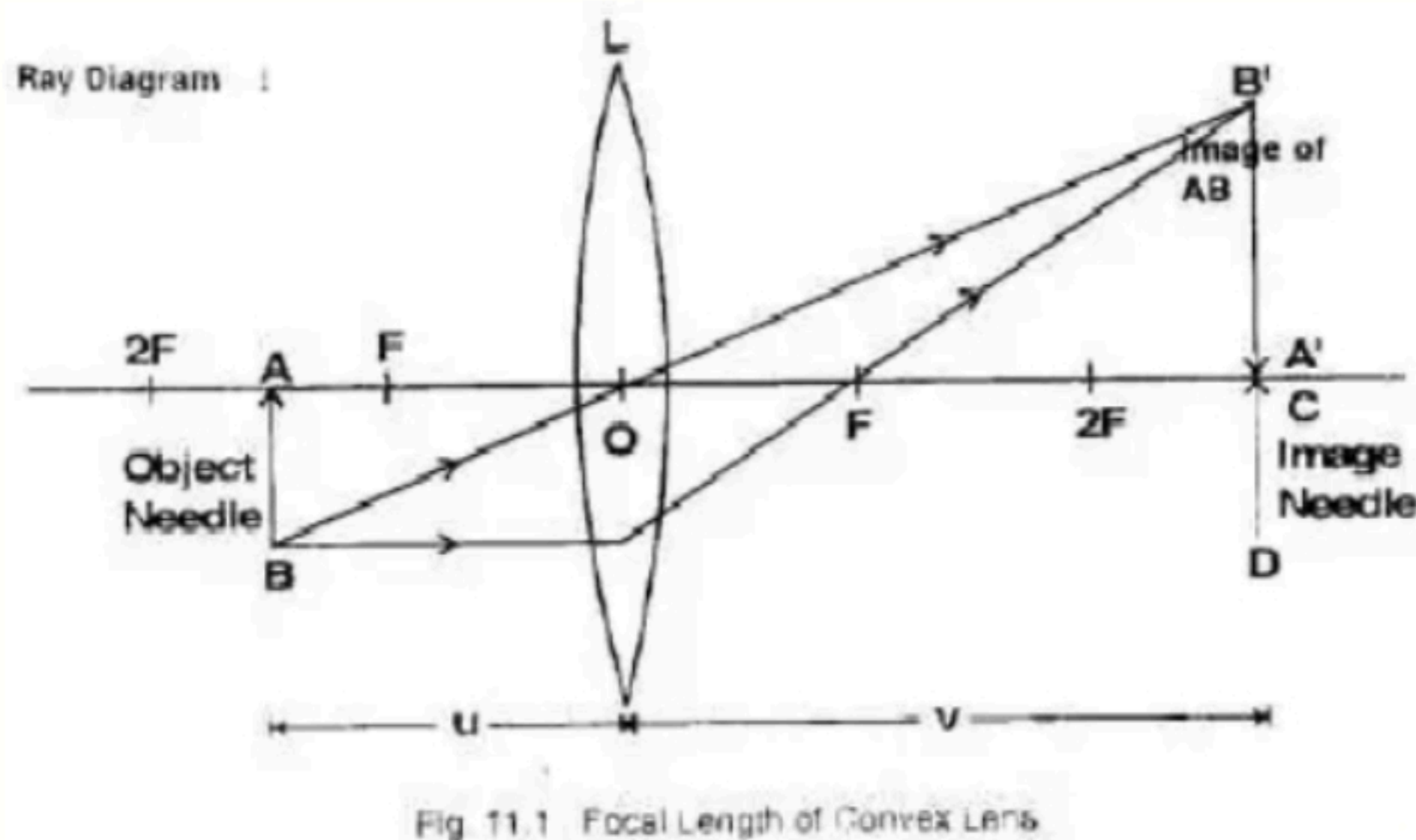
**Aim:** To find the focal length of a convex lens by plotting a graph:

(i) between  $u$  and  $v$

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

$$\frac{1}{u} \quad \text{and} \quad \frac{1}{v}$$

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



### Formula Use d:

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) | $1/u$ (cm <sup>-1</sup> ) | $1/v$ (cm <sup>-1</sup> ) |
|--------|-------------------|------|--------------|----------|----------|---------------------------|---------------------------|
|        | 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:

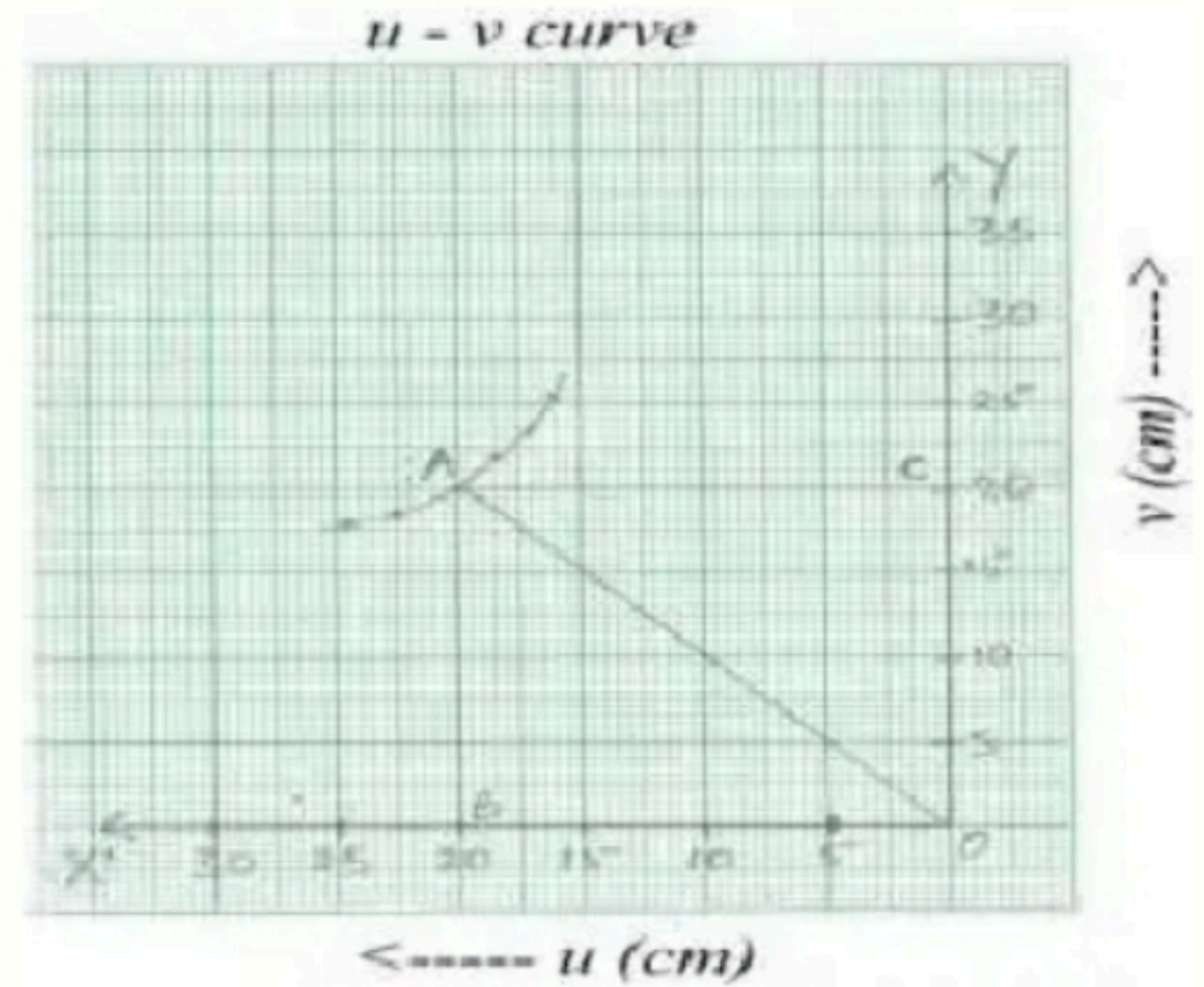
(i)  $u-v$  graph: The graph is a rectangular hyperbola:

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

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

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

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



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

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

Scale; X' axis: 1 cm = 0.01 cm<sup>-1</sup> of  $\frac{1}{u}$

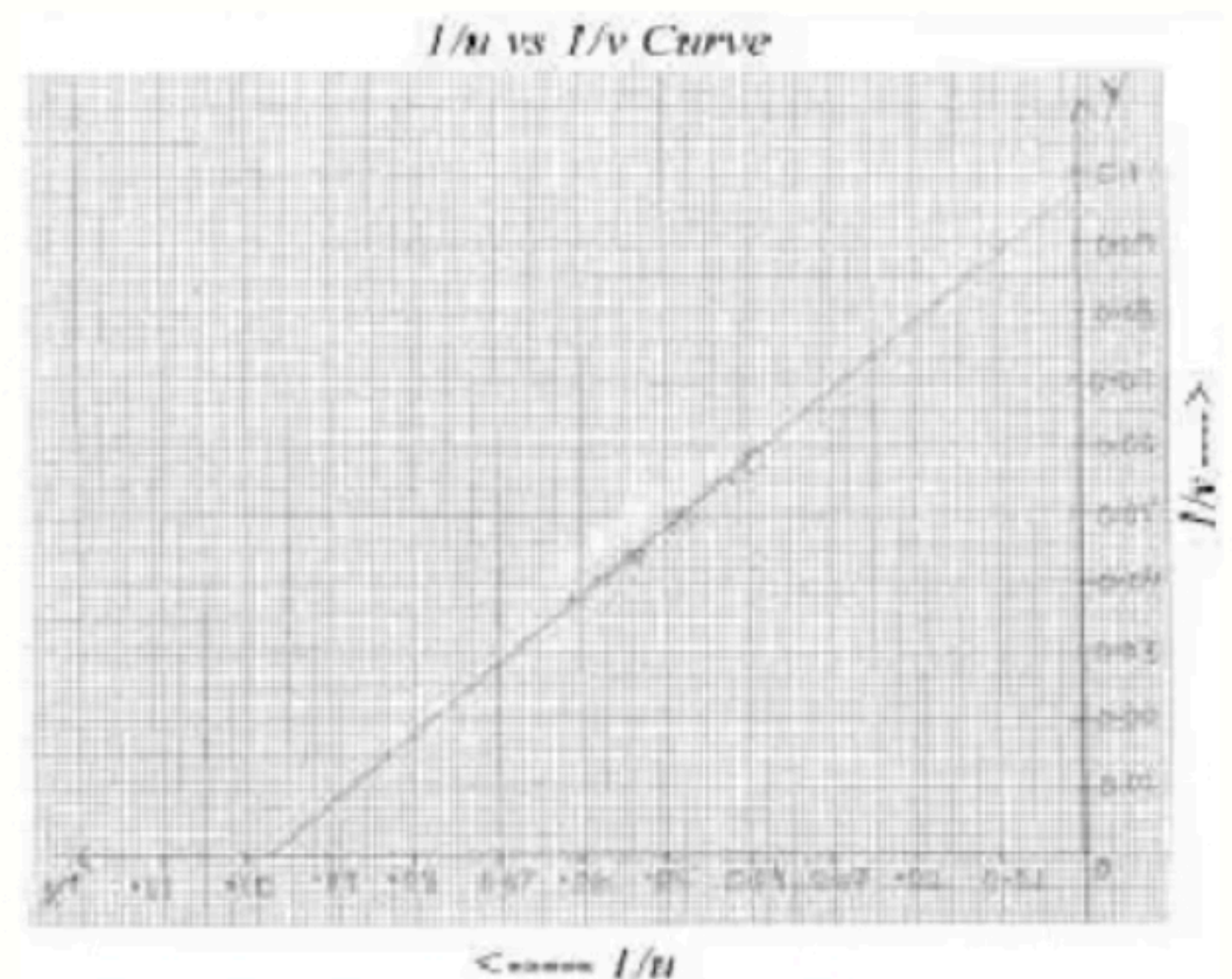
Y' axis: 1 cm = 0.01 cm<sup>-1</sup> of  $\frac{1}{v}$

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

#### 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.

**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.

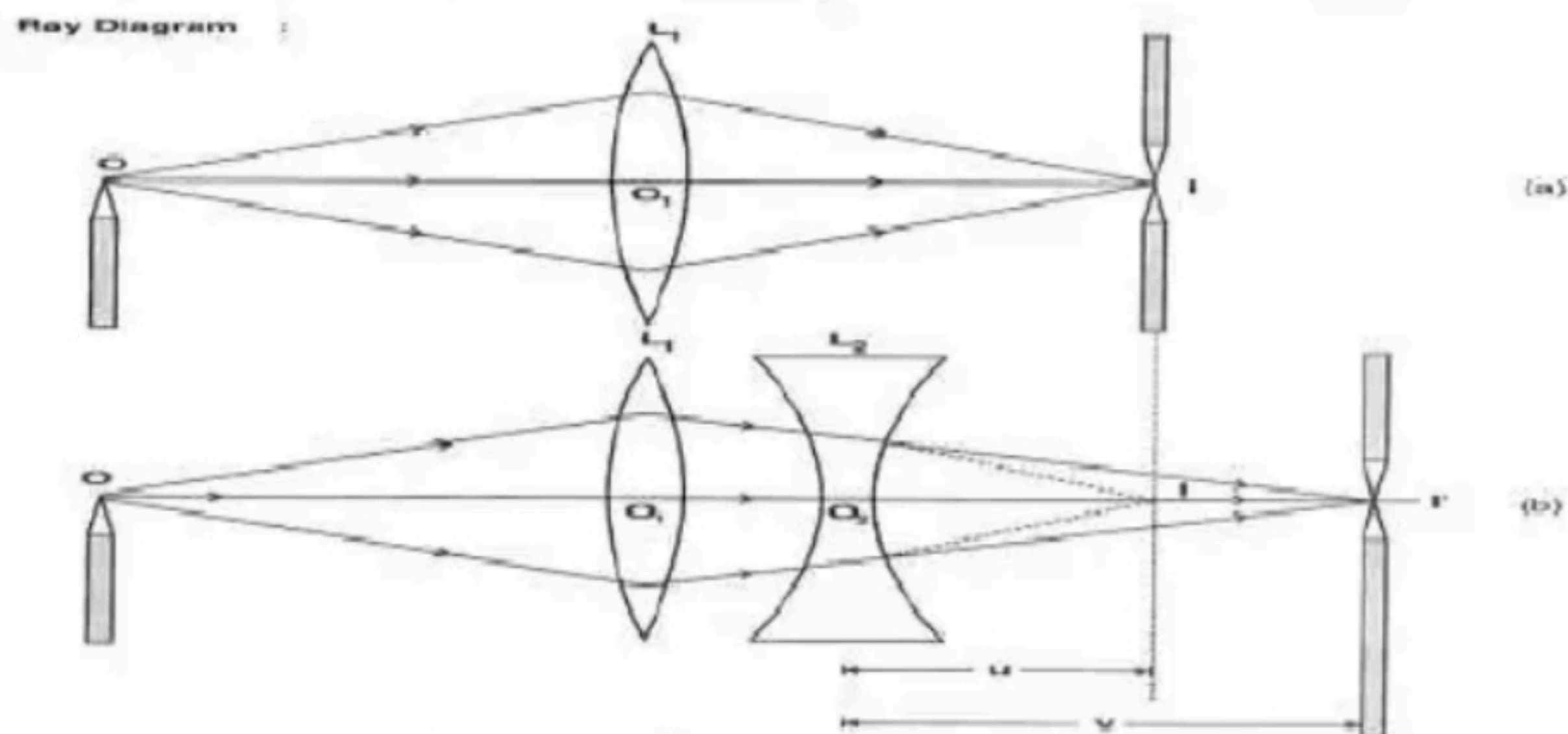


Fig. 12.1 : Focal Length of a concave lens.

**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) |                |      |       |      | $u = OL_2$ | $v = I'L_2$ | $f = \frac{uv}{u - v}$ |
|--------|------------------|----------------|------|-------|------|------------|-------------|------------------------|
|        | O (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:**

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

$$= -16.9 \text{ cm} \approx -17 \text{ cm.}$$

**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.

**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.

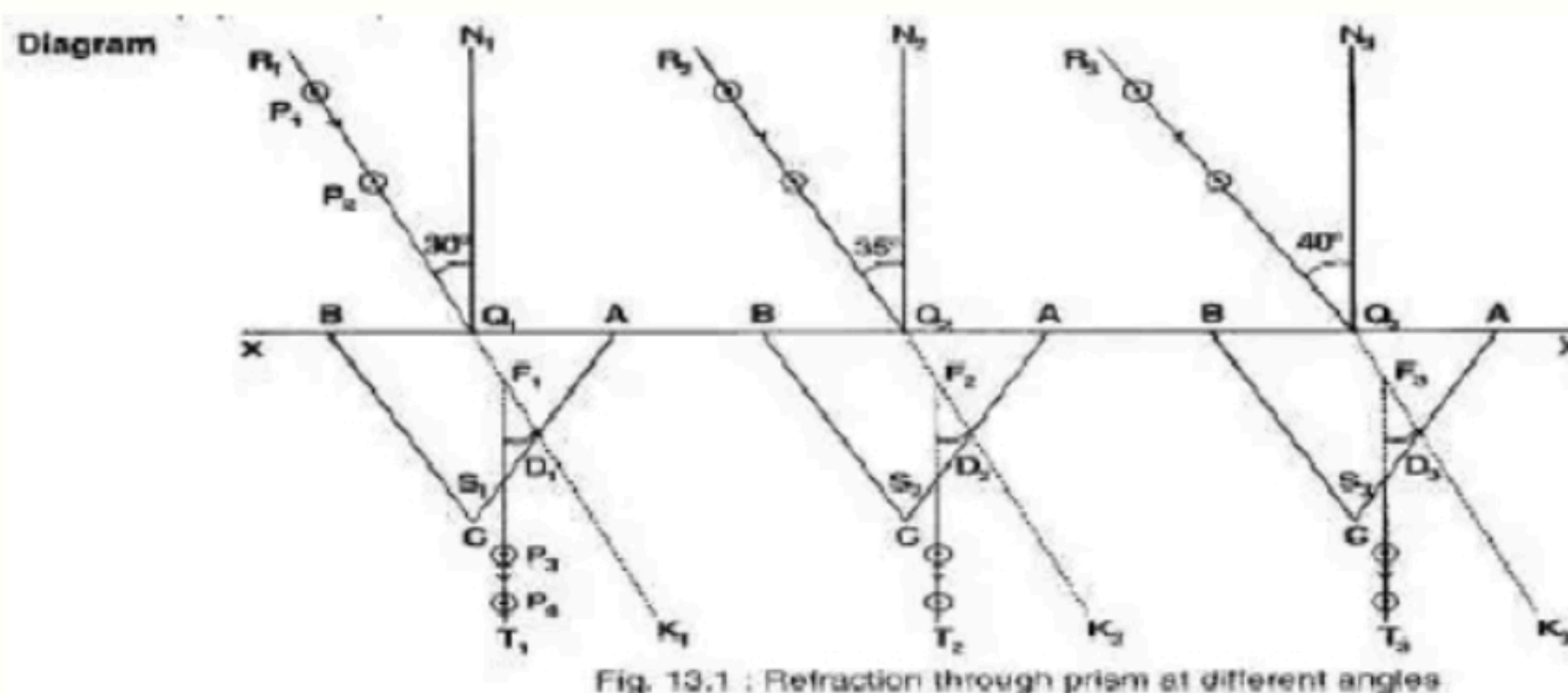


Fig. 13.1 : Refraction through prism at different angles.

**Formulae Used:**

The refractive index,  $\mu$  of the material of the prism is given by:

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

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

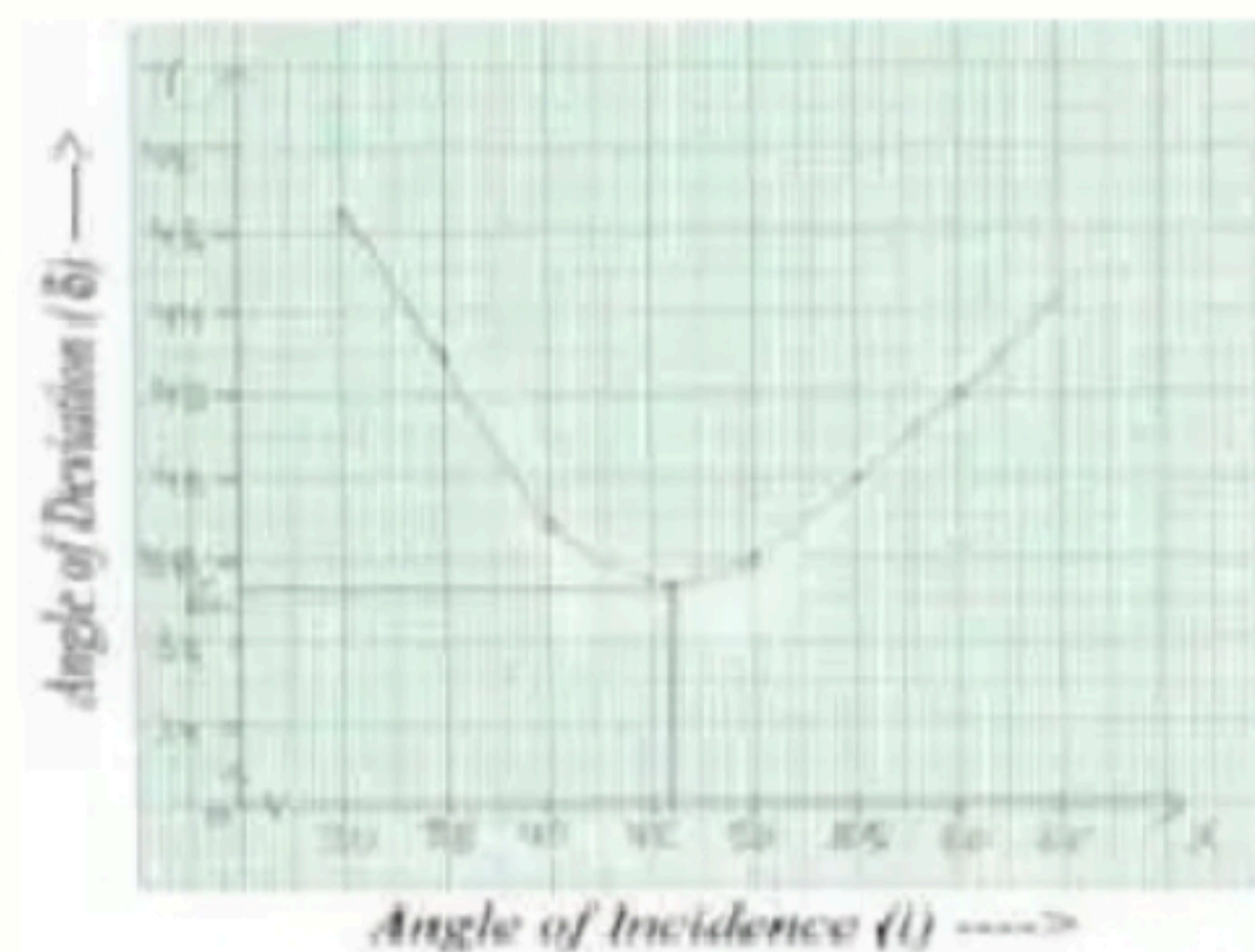
**Calculations:**

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

Thus, 
$$\mu = \frac{\sin\left(\frac{A + D_m}{2}\right)}{\sin\left(\frac{A}{2}\right)} = \frac{\sin\left(\frac{97.8^\circ}{2}\right)}{\sin 30^\circ}$$

$$\mu = 1.5077$$

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



**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 =  $D_m = 37.8^\circ$
- (iii) Refraction index of material of prism,  $\mu = 1.5077$

**Precautions:**

- (i) The angle of incidence should be between  $30^\circ - 60^\circ$ .
- (ii) The pins should be fixed vertical.
- (iii) The distance between the two pins should not be less than 8 cm.