UNIT IV

How Things Work

Experiment 48

AIM

To study the dependence of the potential difference across a resistor on the current through it and to determine its resistance and to verify the Ohm's law.

THEORY

According to the Ohm's law, the potential difference (V) across the ends of a resistor is directly proportional to the current (I) through it provided its temperature remains the same. That is

$$V \propto I$$

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

or $V = RI.$

Here R is a constant for the given resistor at a given temperature and is called its resistance. The SI unit of resistance is ohm (Ω). A graph between the potential difference across the two ends of a resistor and the current through it is a straight line pasing through the origin. The slope of this graph gives the resistance R of the resistor. To verify the Ohm's law, we measure the potential difference across the two ends of a resistor at different currents through it in an electric circuit. The current through the resistor is measured by connecting an ammeter in series with it. The potential difference across the two ends of the resistor is measured by connecting the voltmeter in parallel with it. A straight line graph obtained between V and I verifies the ohm's law.
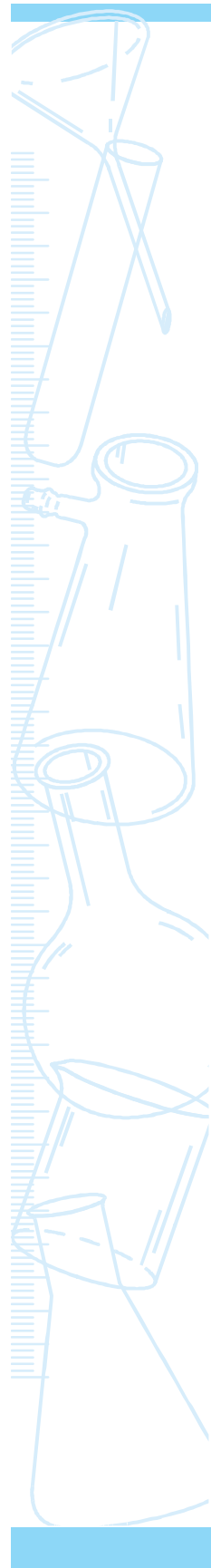
MATERIALS REQUIRED

A resistor of about 5 Ω, an ammeter (0 - 3 A), a voltmeter (0 - 10 V), four dry cells of 1.5 V each with a cell holder (or a battery eliminator), a plug key, connecting wires, and a piece of sand paper.

PROCEDURE

1. Note the range and least count of the given ammeter and the voltmeter.

2. Fresh connecting wires have an insulating layer on it. Similarly the connecting wires lying unused for some time may also develop an insulating layer. (How?) It is therefore important to clean the ends of connecting wires using a sand paper.

3. Draw a circuit diagram for studying the Ohm's law as shown in Fig. 48.1 in your notebook. Observe how different components like the ammeter, voltmeter, resistor, and the plug key are connected with the cells (or battery eliminator).

4. Set up the circuit by connecting different components with the help of connecting wires. Initially connect only one cell in the circuit (that is make cell connections between points A and B). In case a battery eleminator is used, keep the rating of the eliminator at the minimum (say at 2 V).
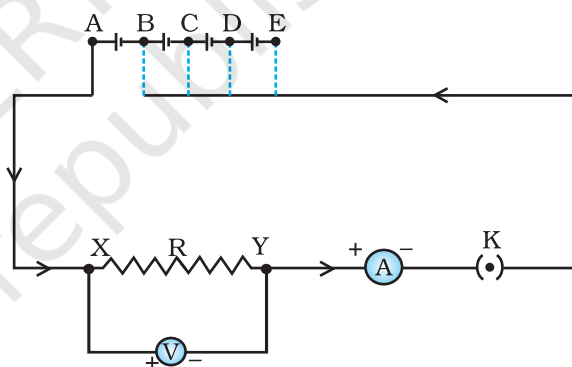
Fig. 48.1 : *An electric circuit for studying Ohm's law*

5. Make sure that the positive and negative terminals of the ammeter and voltmeter are **correctly** connected in the circuit as shown in Fig. 48.1. **Get the circuit set up by you checked by the teacher, before inserting the key into the plug**.

6. Insert the key in the plug to let the current establish in the circuit. Note the readings of the ammeter and voltmeter and record them. The voltmeter measures the potential difference (*V*) across the two ends X and Y of the resistor, and the ammeter measures the current *I* through it. Remove the key from the plug to avoid unnecessary heating of wires. (How does it happen? Think it in accordance with the Joule's law of heating.)

7. Now instead of using one cell in the circuit, connect two cells in the circuit (that is make cell connections between points A and C, in case

a battery eliminator is used, increase its rating. Insert the key in the circuit. Note and record the voltmeter and ammeter readings.

8. Repeat the experiment by connecting three and four cells in the circuit.

OBSERVATIONS AND CALCULATIONS

(i) Range of the ammeter = ___ - ___ A.
(ii) Least count of the ammeter = ___ A.
(iii) Range of the voltmeter = ___ – ___ V.
(iv) Least count of the voltmeter = ___ V.

Mean value of resistance R of the resistor = _____ Ω.

| Sl. No.	Number of cells used in the circuit	Current through the resistor, I	Potential difference across the ends of the resistor, V	Resistance of the resistor, R = V/I
		(A)	(V)	(Ω)
1.	1			
2.	2			
3.	3			
4.	4			

GRAPH

Find the range of variation in the values of I and V. Choose appropriate scales for the I and V along the x- and y-axes respectively on the graph paper. Mark the points on the graph paper for each value of current I and corresponding value of potential difference V (Fig. 48.2). Join all the points as a smooth line as possible such that most of the points lie on it. Find the slope of this straight line graph by choosing two points P and Q on it. This slope is the resistance of the resistor used in the circuit (Fig. 48.1).

$$\text{slope} = \frac{QM}{MP}$$

$$= \frac{V_2 - V_1}{I_2 - I_1}.$$

Extend the straight line of the graph backwards to check whether it meets the origin of the graph paper.
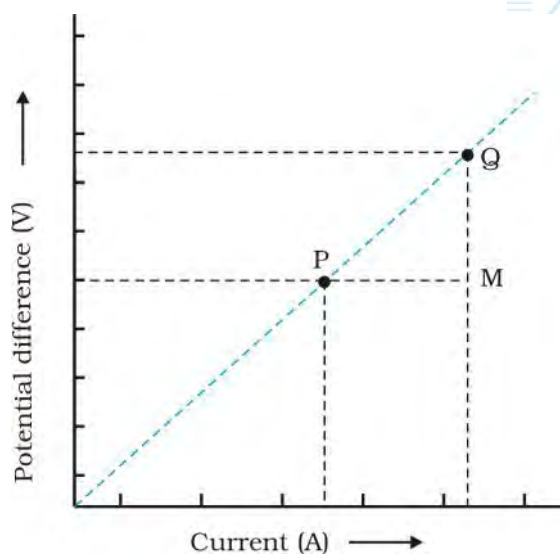
Fig. 48.2 : *Verification Ohm's law*

Results and Discussion

- Compare the value of resistance R of the resistor obtained from the calculations (as given in the observation table) and obtained from the graph.
- The value of resistance R of resistor for all values of current through it remains the same (or almost same). The graph between V and I is a straight line and passes through the origin. This verifies the Ohm's law.

Precautions and Sources of Error

- The connecting wires should be thick copper wires and the insulation of their ends should be removed using the sand paper.
- Connections should be tight otherwise some external resistance may introduce in the circuit.
- The ammeter should be connected in series with the resistor such that the current enters at the positve terminal and leaves at the negative terminal of the ammeter.
- Voltmeter should always be connected in parallel to resistor.
- The pointers of the ammeter and voltmeter should be at zero mark when no current through the circuit. If not, then ask your teacher to correct it.
- Current should be passed through the circuit for a short time while taking observations; otherwise current would cause unnecessary heating in the circuit. Heating may change the resistance of resistors.

Note for the Teacher

- If a resistor of known resistance is not available, a piece of nichrome wire of suitable length may also be used.
- In place of dry cells, Leclanche, Daniel cells can be used. A battery eliminator may also be used. In case a battery eliminator is used, it is suggested to guide students accordingly while connecting it in the circuit and taking observations.
- In case if an accumulator or battery is used in place of cells or eliminator to draw the current in the circuit then a rheostat or variable resistance box can be used to change the current flowing through the circuit.
- In case your school laboratory possesses the voltmeter and ammeter of ranges other than the prescribed ranges, then the resistors may be so chosen that an appreciable deflection may appear in the ammeter and voltmeter.

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QUESTIONS

- In this experiment it is advised to take out the key from the plug when the observations are not being taken. Why?

- Suppose the ammeter (or voltmeter) you are using in this experiment do not have positive (+) and negative (-) terminal markings. How will you use such ammeter (or voltmeter) in the circuit?

- If the resistor of a known resistance value is replaced with a nichrome wire of 10 cm length (say). How do the values of current through the nichrome wire and potential difference across the two ends of it may change? How the values will change if the replaced wire is of manganin in place of nichrome?

- Suppose in this experiment you see that the deflection on ammeter (or voltmeter) scale goes beyond the full scale. What will you infer from such an observation? What will you infer if the deflection takes place in opposite direction?

- Why is it advised to clean the ends of connecting wires before connecting them?
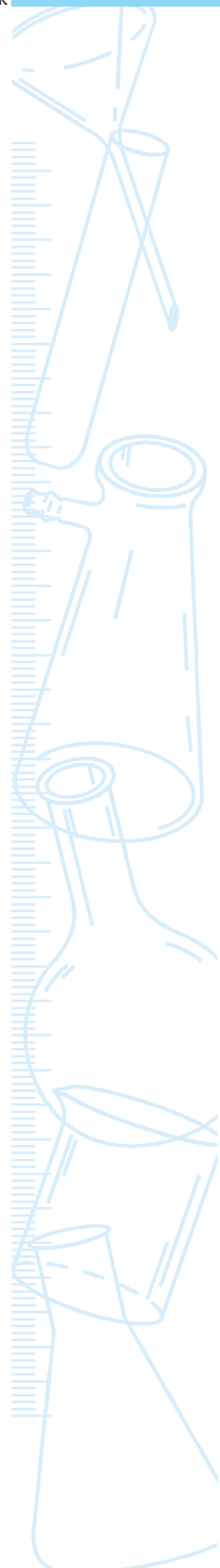
Experiment **49**

AIM

To study the factors that affect the resistance of a resistor.

THEORY

On applying the Ohm's law, it is observed that the resistance of a resistor depends on its length, on its area of cross-section and on the nature of its material. Precise measurements have shown that the resistance (R) of a uniform metallic conductor is directly proportional to its length (l) and inversely proportional to the area of cross-section (A). That is, $R \propto l$ and $R \alpha \dfrac{1}{A}$. Thus

$$R = \rho \frac{l}{A} \tag{1}$$

Here ρ is a constant of proportionality and is called the electrical resistivity of the material of the conductor. The SI unit of resistivity is ohm meter (Ω m).

In this experiment, we study these factors in an electric circuit by employing different resistors (wires) of different lengths and areas of cross-section. Using Ohm's law, the resistance of a conductor in an electric circuit can be determined by measuring the current through it and potential difference across its ends. An ammeter (connected in series with the resistor) measures the current through it and a voltmeter (connected parallely with the resistor) measures the potential difference across its two ends.

MATERIALS REQUIRED

Two SWG-20 (standard wire gauge) constantan (or manganin) wires of lengths 10 cm and 20 cm respectively, one SWG-24 constantan (or manganin) wire of 10 cm length, one SWG-20 (or SWG-24) nichrome wire of 10 cm length (all wires must be attached with the connectors at both the ends such as crocodile clips), an ammeter (range 0 – 500 mA), a voltmeter (range 0 – 5 V), four dry cells of 1.5 V each with a cell holder (or a battery eliminator), a plug key, crocodile clips, connecting wires and a piece of sand paper.

The area of cross-section of a SWG-20 wire: 5.178×10^{-7} m²; and the area of cross-section of a SWG-24 wire: 2.05×10^{-7} m².

PROCEDURE

1. Note the range and least count of the given ammeter and the voltmeter.

2. Fresh connecting wires have an insulating layer at the top. Similarly the connecting wires lying unused for some time may also develop an insulating layer. (How?) It is therefore important to clean the ends of connecting wires using a sand paper.

3. Draw a circuit diagram for studying the factors that affect the resistance of a resistor, as shown in Fig. 49.1 in your notebook. Observe how different components like the ammeter, voltmeter, and the plug key are connected with the cells or battery eliminator. Note that a resistor is to be connected in the circuit between points A and B.

4. Set up the circuit by connecting different components with the help of connecting wires. Connect all the four cells in the circuit. In case if a battery eliminator is used, keep the rating of the eliminator at about 6 V.

5. Label the given wires (resistors) as following:

   SWG-20 constantan (or manganin) wire of length 10 cm as **wire 1**, SWG 20 constantan (or manganin) wire of length 20 cm as **wire 2**, SWG-24 constantan (or manganin) wire of length 10 cm as **wire 3**, and SWG-20 (or SWG-24) nichrome wire of length 10 cm as **wire 4**.
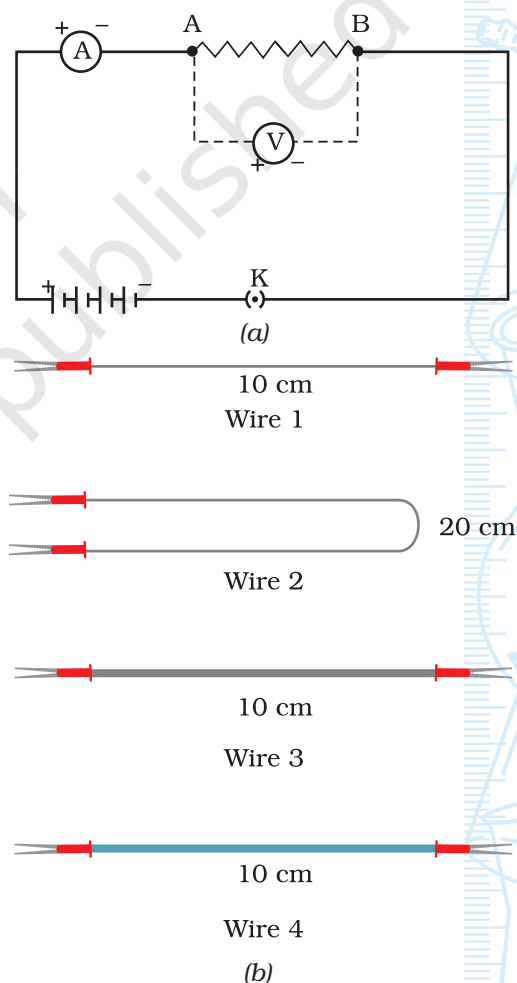
Fig. 49.1 : (a) Electric circuit for studying the factors that affects the resistance of a resistor; (b) Different wires to be used as resistor

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All the wires must be attached to connectors such as crocodile clips, as shown in Fig. 49.1(b). This will ensure that the entire length of the wire will come in the circuit as a resitor.

6. Connect wire 1 between points A and B. Make sure that the positive and negative terminals of the ammeter and voltmeter are **correctly** connected in the circuit as shown in Fig. 49.1. **Get the circuit checked by the teacher, before inserting the key into the plug**.

7. Insert the key in plug to let the current establish in the circuit. Note the readings of the ammeter and voltmeter and record them. Ensure that the key is removed from the plug just after taking the ammeter and voltmeter readings to avoid unnecessary heating of wires.

8. Now replace the wire 1 by the wire 2. Insert the key in the plug and measure the current through wire 2 and measure the potential difference across the ends of the wire 2. Notice the difference in the values of current and potential difference. Remove the key.

9. Repeat step 8 for wires 3 and 4.

OBSERVATIONS AND CALCULATIONS

(i) Range of the ammeter = ___ - ___ A.
(ii) Least count of the ammeter = ___ A.
(iii) Range of the voltmeter = ___ – ___ V.
(iv) Least count of the voltmeter = ___ V.

Sl. No.	Label of the Resistor connected between points A and B	Current through the resistor, I		Potential difference across the ends of resistor, V	Resistance of the resistor, $R = V/I$
		(mA)	(A)	(V)	(Ω)
1.	Wire 1				
2.	Wire 2				
3.	Wire 3				
4.	Wire 4				

RESULTS AND DISCUSSION

Infer about the factors that affects the resistance of a resistor and answer the following:

• How does it change with length?

• How does it change with the area of cross-section?

• How does it change with the resistivity of the material of the wire? (Get the resistivity of the materials from the textbook/Appendix - I).

PRECAUTIONS

- The connecting wires should be thick copper wires and the insulation of their ends should be removed using the sand paper.
- Connections should be tight otherwise some external resistance may introduce in the circuit.
- The ammeter should be connected in series with the resistor such that the current enters at the positve terminal and leaves at the negative terminal of the ammeter.
- Voltmeter should always be connected in parallel to resistor.
- The pointers of the ammeter and voltmeter should be at zero mark when no current is flowing through the circuit. If not, then ask your teacher to correct it.
- Current should be passed through the circuit for a short time while taking observations; otherwise current would cause unnecessary heating in the circuit. Heating may change the resistance of resistors.

NOTE FOR THE TEACHER

- The number of cells to be used in the circuit is not fixed. The number of cells or the rating of the battery eliminator will, however, depend on the wires to be used as resistors in the circuit to give an appreciable amount of current to be measured by the ammeter.
- In place of dry cells a battery eliminator or a 9 V battery may be used. In case a battery eliminator is used, it is suggested to guide students accordingly while connecting it in the circuit and taking observations.
- In case your school laboratory possesses the voltmeter and ammeter of ranges other than the prescribed ranges, then the resistors may be chosen such that an appreciable deflection may appear on the ammeter and voltmeter scales.
- In this experiment it is suggested to use SWG-20 and SWG-24 constantan (or manganin) and nichrome wires. However this is suggestive and not mandatory. In case, these are not available other wires may also be used. It is suggested that the choice of wires should be judicious to get an appreciable deflection on the scales of the ammeter and voltmeter available in the laboratory. Further the area of cross-section of each wire should also be provided to the students. Appendix - J may be consulted for this purpose. In case if the standard wire gauge of the wires are not known, the diameter of the wire may be determined using a screw gauge.

QUESTIONS

- A thick and a thin wire of same length and material are connected to the same source. Which of the two will draw more current from the source?
- A copper wire is stretched uniformly to double its length; how will its resistance change? Will its resistivity also be changed?
- What happens to the value of current if positions of battery and ammeter are interchanged in such a manner that the current enters at the positive terminal of the ammeter?
- On what factors does the resistance of a conductor depend?
- If the plug key is interchanged by the ammeter in this experiment, would you be able to perform the experiment?
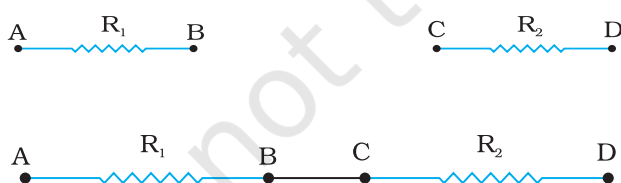
Experiment 50

AIM

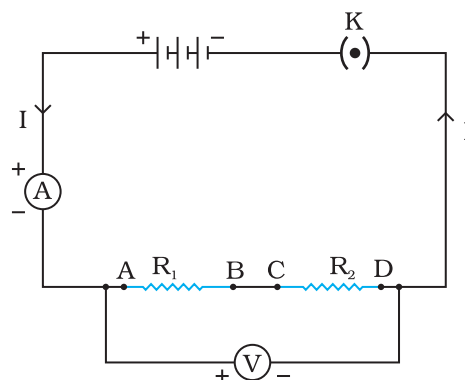To determine the equivalent resistance of two resistors connected in series combination.

THEORY

When two resistors of resistance R_1 and R_2 respectively are connected in a series combination (Fig. 50.1), then their equivalent resistance R_s is given by

$$R_s = R_1 + R_2. \tag{1}$$

Fig. 50.1: *(a) Two resistors AB and CD are placed one after the other; (b) Two resistors AB and CD are connected in a series combination*

Fig. 50.2 : *Circuit diagram for the series combination of two resistors AB and CD*

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In order to determine the resistance of a combination of resistors in series, the current I flowing through the circuit is measured with an ammeter connected in series with the combination. The potential difference V across the combination of resistors is measured with a voltmeter connected in parallel (Fig. 50.2).

MATERIALS REQUIRED

Two resistors of (each of 2 W resistance), an ammeter (range 0 – 5 A), a voltmeter (range 0 – 5 V), three dry cells of 1.5 V each with a cell holder (or a battery eliminator), a plug key, connecting wires and a piece of sand paper.

PROCEDURE

1. Note the range and least count of the given ammeter and the voltmeter.
2. Fresh connecting wires also have an insulating enamel layer at the top. Similarly the connecting wires lying unused for some time may also develop an insulating layer. (How?) It is therefore important to clean the ends of connecting wires using a sand paper.
3. Draw a circuit diagram for the series combination of resistors as shown in Fig. 50.2 in your notebook. Observe how different components like the ammeter, voltmeter, combination of resistors in series (of known resistances R_1 and R_2) and the plug key are connected with the cell(s) (or battery eliminator).
4. Place the given resistors one after the other and join the ends labelled B and C as shown in Fig. 50.1. Set up the circuit by connecting different components with the help of connecting wires as shown in the circuit diagram.
5. Make sure that the positive and negative terminals of the ammeter and voltmeter are correctly connected in the circuit as shown in Fig. 50.2. Get the circuit set up by you checked by the teacher, before inserting the key into the plug.
6. Insert the key in the plug to let the current establish in the circuit. Note the readings of the ammeter and voltmeter and record them. The voltmeter measures the potential difference (V) across the two ends A and D of the series combination of two resistors, and the ammeter measures the current I through the series combination. Remove the key from the plug to avoid unnecessary heating of wires (How does it happen? Think it in accordance with the Joule's law of heating.)
7. Repeat the activity for three different values of current through the circuit and record the readings of the ammeter and voltmeter in each case. The current through the circuit may either be decreased or

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increased by changing the number of cells in the circuit (or by changing the settings of the battery eliminator terminal).

OBSERVATIONS AND CALCULATIONS

Range of the ammeter = ___ - ___ A.
Least count of the ammeter = ___ A.
Range of the voltmeter = ___ - ___ V.
Least count of the voltmeter = ___ V.
Resistance of first resistor R_1 = ___ Ω.
Resistance of second resistor, R_2 = ___ Ω.

Sl. No.	Number of cells in the circuit	Current through the series combination, I_S	Potential difference across the series V_S	Equivalent Resistance of combination, R_S $R_S = V_s/I_s$	Average value of R_S
		(A)	(V)	(Ω)	(Ω)
1.					
2.					
3.					
4.					

R_1 = ____ Ω, R_2 = _____ Ω
Equivalent resistance [from Eq. (1)] = $R_1 + R_2$ = ___ Ω

RESULTS AND DISCUSSION

Compare the observed value of the equivalent resistance of the series combination of the two given resistors (from observation table) with the calculated value of it using Eq. (1).

PRECAUTIONS

• The connecting wires should be thick copper wires and the insulation of their ends should be removed using the sand paper.
• Connections should be tight otherwise some external resistance may introduce in the circuit.
• The ammeter should be connected in series with the combination of resistors such that the current enters at the positve terminal and leaves at the negative terminal of the ammeter.
• Voltmeter should always be connected in parallel to the combination of resistors.
• The pointers of the ammeter and voltmeter should be at zero mark when no current flows through the circuit. If not, then ask your teacher to correct it.

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- Current should be passed through the circuit for a short time while taking observations; otherwise current would cause unnecessary heating in the circuit. Heating may change the resistance of resistors.

NOTE FOR THE TEACHER

- The internal resistance of cells should be much lower than the resistance of external resistors used in the experiment.
- In case if an accumulator or battery is used in place of cells or eliminator to draw the current in the circuit then a rheostat or variable resistance box can be used to change the current flowing through the circuit.
- In case your school laboratory possesses the voltmeter and ammeter of ranges other than the prescribed ranges, then the resistors may be chosen such that an appreciable deflection may appear in the ammeter and voltmeter.

QUESTIONS

- If two resistors having resistances of 2 Ω and 4 Ω, respectively are connected in a series combination in an electric circuit, what will be the net resistance in the circuit?
- In an electric circuit, a resistor of 5 Ω resistance is connected to a battery (5 V) through an ammeter and a plug key. Now in this circuit an another resistor of 10 Ω is connected in series with the 5 Ω resistor. Will there be any change in the ammeter reading? How much?
- In above question, what is the potential difference across the two ends of the resistor of 5 Ω resistance, when it is alone in the circuit? What is the potential difference across the two ends of resistor of 5 Ω resistance when it is connected in series with the resistor of 10 Ω resistance. What is the potential difference across the series combination?

Experiment 51

AIM

To determine the equivalent resistance of two resistors connected in parallel combination.

THEORY

When two resistors of resistance R_1 and R_2 respectively are connected in a parallel combination (Fig. 51.1), then their equivalent resistance R_p is given by

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

or

$$R_p = \frac{R_1 R_2}{R_1 + R_2} \qquad (1)$$

In order to determine the resistance of a combination of resistors connected in parallel, the current I flowing through the circuit is measured with an ammeter connected in series with the combination. The potential difference V across the combination of resistors is measured with a voltmeter connected in parallel (Fig. 51.2).
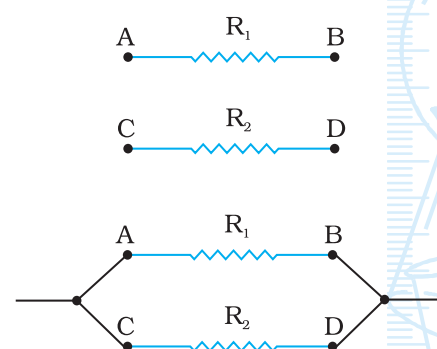
Fig. 51.1 : *(a) Two resistors AB and CD are placed side by side; (b) Two resistors AB and CD are connected in a parallel combination*

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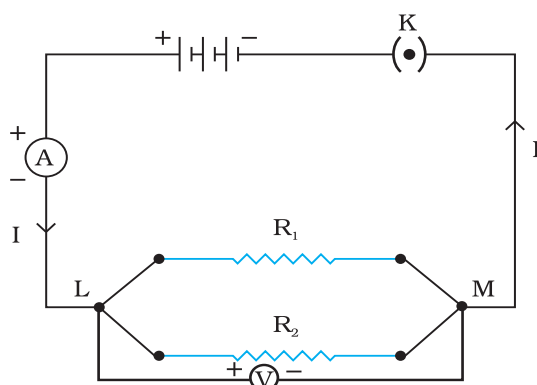
Fig. 51.2 : *Circuit diagram for the series combination of two resistors AB and CD*

MATERIALS REQUIRED

Two resistors of (each of 2 Ω resistance), an ammeter (range 0 – 5 A), a voltmeter (range 0 – 5 V), three dry cells of 1.5 V each with a cell holder (or a battery eliminator), a plug key, connecting wires, and a piece of sand paper.

PROCEDURE

1. Note the range and least count of the given ammeter and the voltemeter.

2. Fresh connecting wires also have an insulating enamel layer at the top. Similarly the connecting wires lying unused for some time may also develop an insulating layer. (How?) It is therefore important to clean the ends of connecting wires using a sand paper.

3. Draw a circuit diagram for the series combination of resistors as shown in Fig. 51.2 in your notebook. Observe how different components like the ammeter, voltmeter, combination of resistors in parallel (of resistances R_1 and R_2) and the plug key are connected with the cell(s) (or battery eliminator).

4. Place the given resistors side by side and join end A with the end C, and end B with end D (Fig. 51.1). Set up the circuit by connecting different components with the help of connecting wires as shown in the circuit diagram (Fig. 51.2).

5. Make sure that the positive and negative terminals of the ammeter and voltmeter are correctly **connected** in the circuit. **Get the circuit set up checked by the teacher, before inserting the key into the plug**.

6. Insert the key in the plug to let the current establish in the circuit. Note the readings of the ammeter and voltmeter and record them. The voltmeter measures the potential difference (V) across the two

ends A and D of the series combination of two resistors, and the ammeter measures the current *I* through the series combination. Remove the key from the plug to avoid unnecessary heating of wires (How does it happen? Think it in accordance with the Joule's law of heating.)

7. Repeat the activity for three different values of current through the circuit and record the readings of the ammeter and voltmeter in each case. The current through the circuit may either be decreased or increased by changing the number of cells in the circuit (or by changing the settings of the battery eliminator terminal).

OBSERVATIONS AND CALCULATIONS

(i)   Range of the ammeter   = ____ - ____ A.

(ii) Least count of the ammeter   = ____ A.

(iii) Range of the voltmeter   = ____ - ____ V.

(iv) Least count of the voltmeter   = ____ V.

(v)   Resistance of first resistor R_1 = ____ Ω.

(vi) Resistance of second resistor, R_2 = ____ Ω.

Sl. No.	Number of cells in the circuit	Current through the parallel combination	Potential difference across the parallel combination, V_p	Equivalent Resistance of combination, R_p $R_p = V_p/I_p$	Average value of R_p
		I_p (A)	(V)	(Ω)	(Ω)
1.					
2.					
3.					
4.					

R_1 = ____ Ω, R_2 = ____ Ω

Equivalent resistance [from Eq. (1)] = $\dfrac{R_1 R_2}{R_1 + R_2}$ = ___ Ω

RESULTS AND DISCUSSION

Compare the observed value of the equivalent resistannce of the parallel combination of the two given resistors (from observation table) with the calculated value of it using Eq. (1).

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PRECAUTIONS AND SOURCES OF ERROR

- The connecting wires should be thick copper wires and the insulation of their ends should be removed using the sand paper.
- Connections should be tight otherwise some contact resistance may introduce in the circuit.
- The ammeter should be connected in series with the combinations of resistors such that the current enters at the positve terminal and leaves at the negative terminal of the ammeter.
- Voltmeter should always be connected in parallel to the combinations of resistors.
- The pointers of the ammeter and voltmeter should be at zero mark when no current through the circuit. If not, then ask your teacher to correct it.
- Current should be passed through the circuit for a short time while taking observations; otherwise current would cause unnecessary heating in the circuit. Heating may change the resistance of resistors.

NOTE FOR THE TEACHER

- The internal resistance of cells should be much lower than the resistance of external resistors used in the experiment.
- In case an accumulator or battery is used in place of cells or eliminator to draw the current in the circuit then a rheostat or variable resistance box can be used to change the current flowing through the circuit.
- In case your school laboratory possesses the voltmeter and ammeter of ranges other than the prescribed ranges, then the resistors may be chosen such that an appreciable deflection may appear in the ammeter and voltmeter.

QUESTIONS

- If two resistors having resistances of 3 Ω, and 6 Ω, respectively are connected in parallel, what will be the net resistance in the circuit?
- Two resistors having resistances of 4 Ω and 6 Ω, respectively are connected in a circuit. It was found that the total resistance in the circuit is less than 4 Ω. In what way the resistances would have been connected?
- Two resistors are connected in series and then in parallel. What effect will it have on the readings of voltmeter and ammeter?
- In what way household appliances should be connected?

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Experiment 52
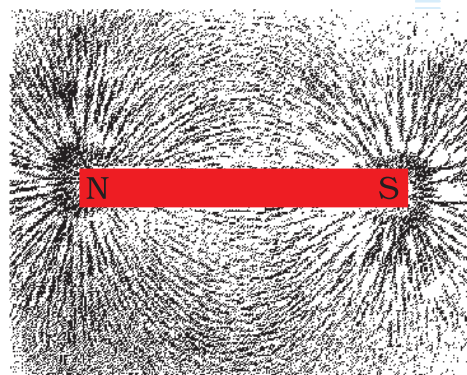
AIM

To draw magnetic field lines of a bar magnet.

THEORY

A field of force that exists around a bar magnet is called its magnetic field. We see that when iron filings are sprinkled around a bar magnet, they arrange in a particular pattern as shown in Fig. 52.1. The lines along which the iron filings orient themselves represent magnetic field lines. These lines are closed curves and do not intersect each other. These field lines are crowded around the poles of the magnet. The degree of their closeness represent that the magnetic field is stronger at poles.

The magnetic field lines around a bar magnet can be obtained using a compass needle. (A compass needle is a small magent. Its one end, which points towards north is called its north pole and the other end, which points towards south is called south pole.)

Fig. 52.1 : *Iron filings near the bar magnetalign themselves along the field lines*

MATERIALS REQUIRED

A bar magnet of about 10 cm, a small compass needle, iron filings, drawing board, adhesive tape or drawing pins of brass, and white paper sheets.

PROCEDURE

(a) To observe the pattern of iron filings around a bar magnet

1. Fix a sheet of white paper on a drawing board using adhesive tape or drawing pins of brass.
2. Place a bar magnet on this sheet in the middle of it.
3. Sprinkle iron filings around the bar magnet and gently tap the drawing board till a pattern, as shown in Fig. 52.1, is formed.
4. Observe the pattern. What does it show? Notice that the iron filings are crowded around the poles of the bar magnet.
5. Remove the iron filings from the paper.

(b) To draw the magnetic field lines around a bar magnet

6. Identify the north and south poles of the bar magnet. Place the bar magnet in the middle of the paper. Mark the position of north and south poles and also draw the boundary of the bar magnet.
7. Place a small compass needle very near the north pole of the magnet.
8. You will observe that the south end of the compass needle aligns itself towards the north pole of the bar magnet.
9. Mark the positions of its two ends of the compass needle.
10. Move the compass to a new position such that its south end occupies the position previously occupied by its north pole.
11. In this way, proceed step-by-step till you reach the south pole of the magnet, as shown in Fig. 52.2.
12. Join the points marked on paper by a smooth curve. This curve represents a field line.
13. Repeat the above procedure and draw as many lines as you can. You will get a pattern like the one shown in
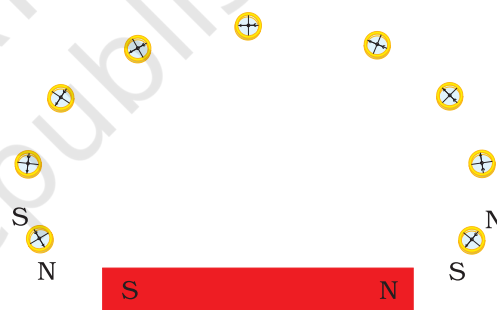
Fig. 52.2 : *Drawing a magnetic field line with the help of a compass needle*
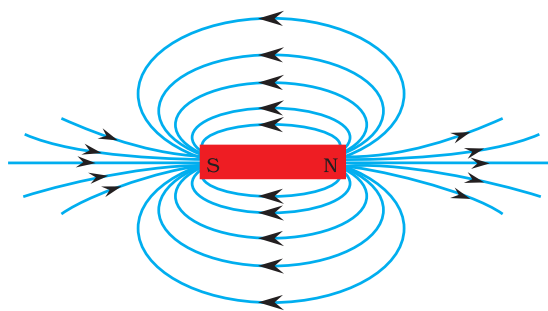
Fig. 52.3 : *Magnetic field lines around a bar magnet*

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Fig. 52.3. You might have noticed that the deflection in the compass needle is more when it is placed closer to one of the poles of the magnet.

OBSERVATIONS AND CALCULATIONS

The attached paper sheet shows the pattern of magnetic field lines drawn around the bar magnet.

RESULTS AND DISCUSSION

From the magnetic field lines around a bar magnet, it may be confirmed that:

- the magnetic field lines are closed and continous;
- the deflection in compass needle increases as it is moves towards the poles;
- two magnetic field lines do not intersect; and
- the magnetic field lines are crowded at poles of the bar magnet.

PRECAUTIONS

- There should not be any other magnetic material near the bar magnet except the compass needle while drawing the magnetic field lines.
- Size of the compass needle should be small.
- The bar magnet should be sufficiently strong to produce an appreciable deflection in the compass needle placed at a distance of 15 cm from the bar magnet.

NOTE FOR THE TEACHER

- If it is found that this experiment, as explained, is difficult to perform within the given time, it may be suggested to draw the magnetic field lines only. The first part to observe the pattern of iron filings around a bar magnet may be skipped.
- North and south poles of a bar magnet can be identified using another magnet of known polarity.
- A small compass needle should be used for drawing the field lines so that sufficient number of field lines can be drawn on a sheet of paper.
- It is advised to place the north and south poles of the bar magnet in the north-south direction. This is to avoid the variation in field patterns due to the effect of earth's magnetic field.

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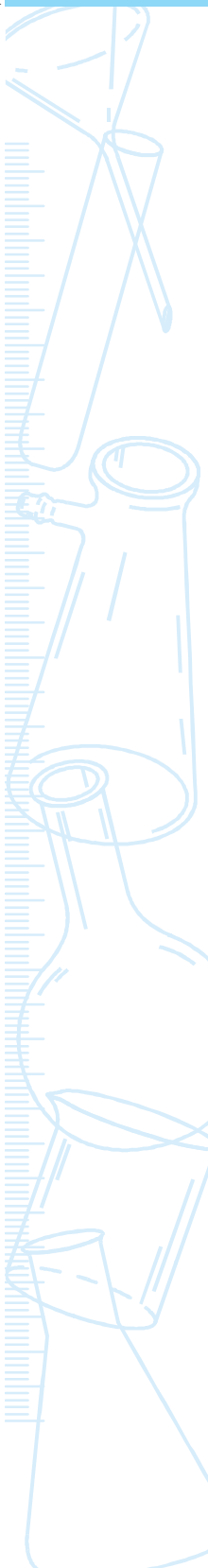
APPLICATIONS

This method can be used to identify the magnetic materials. The strengths of two bar magnets can also be compared.

QUESTIONS

- You are provided an iron strip and a bar magnet. How will you distinguish them?
- How does a compass needle work?
- How will you make a compass using an iron needle, piece of thermo-cole and a magnet?
- Do you think that the needle of a compass is a magnet?
- Why does the needle of a compass point north and south?
- Can an ordinary magnet be used as a compass?
- What does degree of closeness of magnetic field lines indicate?
- Why are more iron filings concentrated around the poles of the magnets?
- In this experiment it is advised to use a small compass needle. What will happen if small compass needle is replaced with a big size compass needle?

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Experiment 53

AIM

To draw the magnetic field lines of a current-carrying straight wire.

THEORY

An electric current through a wire (conductor) produces a magnetic field around it. The existance of magnetic field can be observed using a magnetic compass needle. The direction of the magnetic field depends on the direction of the current through the wire. In this experiment we shall make an attempt to draw the magnetic field lines of a current carrying straight wire and find the effect of change of direction of current through the wire on the magnetic field lines.

MATERIALS REQUIRED

A battery (12 V) or a battery eliminator (12 V/2 A), a variable resistance (a rehostat), a plug key, a thick copper wire (prefereably SWG-12) of about 50 cm length, a rectangular wooden plank with a small hole at the centre through which the thick copper wire may comfortably pass, ammeter (0 - 3 A), a white sheet, a small compass needle, a wooden stand, adhesive tape, connecting wires, and a piece of sand paper.

PROCEDURE

1. Note the range and least count of the given ammeter.
2. Fresh connecting wires also have an insulating enamel layer at the top. Similarly the connecting wires lying unused for some time may

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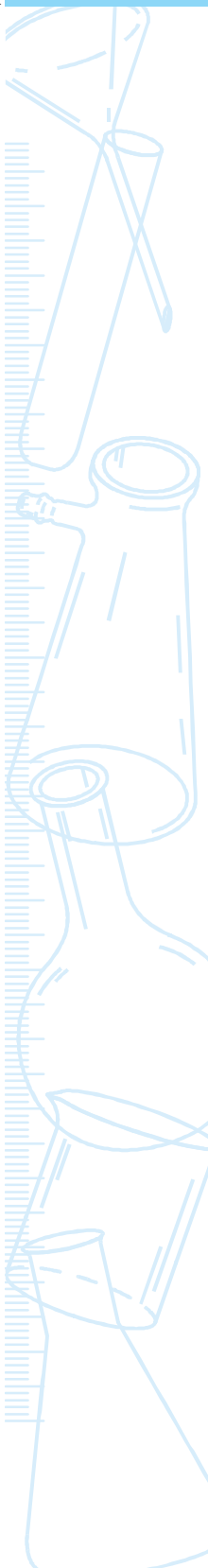
also develop an insulating layer. It is therefore important to clean the ends of connecting wires using a sand paper.

3. Draw a circuit diagram connecting a variable resistance (a rheostat), an ammeter, battery (or a battery eliminator), plug key with the thick copper wire XY as shown in Fig. 53.1.
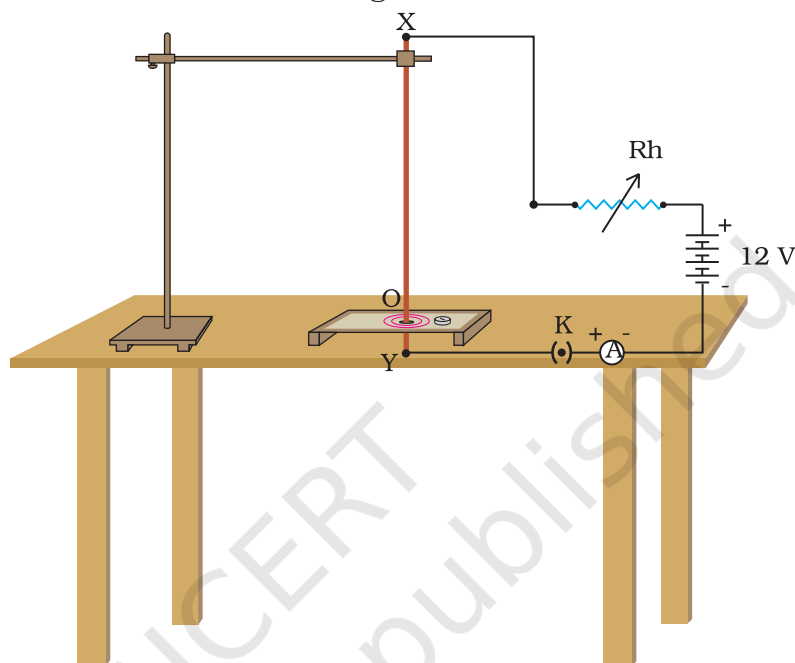
*Fig. 53.1 : An electric circuit to draw the magnetic field lines of a current carrying straight wire*

4. Fix a sheet of white paper on a rectangular wooden plank using adhesive tape. Make a small hole O at the centre of the white sheet such that it overlaps the hole on the plank. Insert the thick copper wire XY through the hole O. Place the plank horizontally on the table as shown.

5. Set up the circuit, as shown in Fig. 53.1, by connecting different components. The position of the thick copper wire XY must be normal to the plane of the rectangular cardboard. The upper end X of the thick copper wire may be fixed on a laboratory (wooden) stand. This will ensure the position of the wire XY to be vertical.

6. Make sure that the positive and negative terminals of the battery (or battery eliminator) and ammeter are **correctly** connected in the circuit. **Get the circuit set up by you checked by the teacher, before inserting the key into the plug**.

7. Insert the key in the plug to let the current flow in the circuit. Change the position of the variable of the rheostat such that a current of about 2 A flows through the thick copper wire XY. Note and record the reading of the ammeter.

8. Place a compass at a point (say P) over the white sheet placed on the rectangular cardboard. Observe the direction of the compass needle. By convention, the direction of the north pole of the compass needle would give the direction of the magnetic field produced by the electric current through the straight wire at point P.

9. Mark the position of the compass needle's two ends and move the compass so that its south end occupies the position previously occupied by its noth end. Again mark the new positions indicated by the two ends of the compass needle. In this way proceed step-by-step till you get a complete circle as shown in Fig 53.1. Also mark the direction of the magnetic field line by an arrow. Thus the magnetic field line of a current carrying straight wire is a circle having the centre at position of the current carrying wire.

10. After drawing one magnetic field line remove the plug key and wait for few minutes so that the wire comes back to its normal temperature.

11. Repeat the above procedure and draw as many concentric circles (representing magnetic field lines) as you can. What happens to the deflection of the needle if the compass is moved away from the thick copper wire. Do you observe that the deflection in the compass needle decreases? What does it mean? It represents that the magnetic field produced by a given current in the conductor decreases as the distance from it increases.

12. Using this circuit, you can also see the effect of change in current through the conductor on the deflection in the compass needle placed at a given point. For this, place the compass needle at a fixed point Q (say). Now by changing the position of the variable contact of the rheostat, increase the current through the thick copper wire. What effect do you observe? The deflection in the compass needle also increases. Do you observe a decrease in the compass needle at a given point Q (say) with a decrease in current through the thick copper wire. It indicates that the magnitude of the magnetic field produced at a given point increases as the current through the thick copper wire increases or vice-versa.

13. Reverse the direction of current through the straight thick copper wire by interchanging the terminals of the battery (or battery eliminator) and observe the direction of the compass needle. Does it get reversed?

OBSERVATIONS

The attached sheet shows the pattern of magnetic field lines around a current-carying straight wire.

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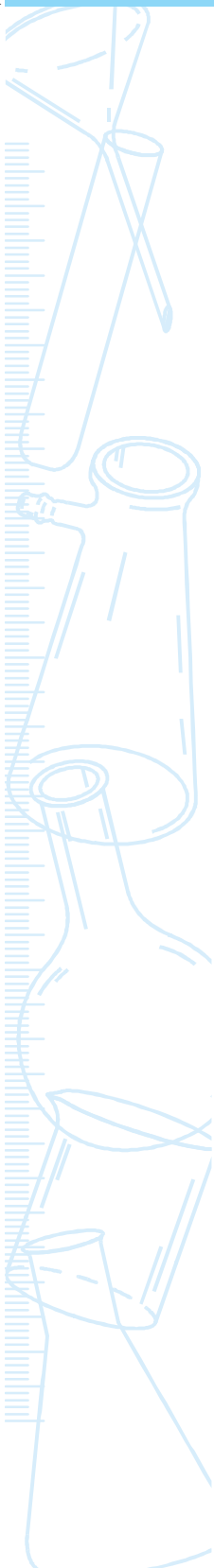
RESULTS AND DISCUSSION

On the basis of observations on the magnetic field lines, the following can be infered:

- The magnetic field lines around a current-carrying straight wire do not intersect each other.
- The deflection in the compass needle decreases as it is moved away from the current carrying straight wire.
- The deflection in the compass needle changes as the current through the wire changes.
- The direction of magnetic field lines gets reversed if the direction of current through the straight copper wire is reversed.

PRECAUTIONS

- Plug key should only be inserted in the circuit when you are recording the observations.
- After drawing one magnetic field line remove the plug key and wait for few minutes so that the wire comes back to its normal temperature.
- Please do not touch the hot wire during the experiment, lest you may hurt yourself as the wire may become very hot.
- There should not be any magnetic material near the current carrying straight wire except the compass needle.
- The thick copper wire XY must be positioned straight and vertical through out the experiment. In case a proper wooden stand is not available, then the wire must be passed through a cork that can be clamped in the laboratory stand.
- A resistor of variable resistance (variable resistor) or rheostat should be connected in series with the thick straight copper wire to regulate the current through the straight copper wire.

NOTE FOR THE TEACHER

- In this experiment a variable resistance (a rheostat) is used to change the resistance in the circuit and thereby to change the current through the circuit. A rheostat may be a new instrument for the students. It is suggested to demonstarte its use as a variable resistor. However in place of a rheostat, a resistance box may also be used in the circuit.
- In this experiment, a high current (about 2 A) is required to flow through the circuit for a longer time. Thus the amount of heat generated will be more (Joule's law of heating). A thin wire may not remain straight for the entire duration of the experiment and

may even melt. It is therefore advised to use a thick copper wire (preferably SWG-12) whose diameter is about 2 mm. In case if it is not available, other wires may also be used. Such thick copper wires are often used in the earthing of domestic electric circuits.

• In this experiment, a relatively higher current flows through the circuit and for this reacson, it requires a high voltage battery or a high capacity battery eliminator.

QUESTIONS

• How magnetic field lines of a straight current carrying wire are different from the field lines of a bar magnet?

• What affect you will notice on the pattern of field lines if you interchange a rheostat by the plug key in this experimental arrangement?

• How can the direction of the magnetic field be determined? Suggest one method.

• What will happen to the pattern of field lines if the thick copper wire is kept horizontally straight instead of vertically straight? Discuss in groups.
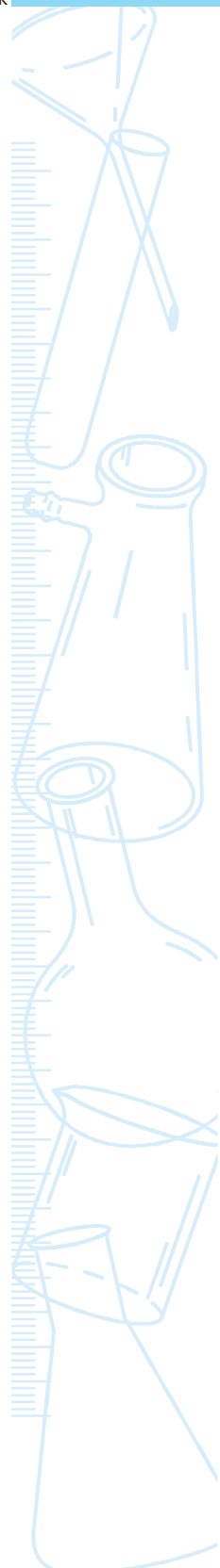
Experiment **54**

AIM

To study the magnetic field of an electromagnet.

THEORY

An electromagnet is a magnet consisting of a soft iron core with a coil of insulated wire wound round it. When a current flows through the wire the core becomes magnetized; when the current ceases to flow, the core loses its magnetization. In this experiment, using a compass needle we shall study the magnetic field produced by an electromagnet. (A compass needle is a small magent. Its one end, which points towards north is called its north pole and the other end, which points towards south is called south pole. A circular scale around the compass needle is used to measure its deflection. We will investigate the variation in the magnetic field produced by the electromagnet by changing the magnitude and direction of the current in the coil; and also the variation in the magnetic field as the compass is moved away from the electromagnet keeping the current through the coil constant.

MATERIALS REQUIRED

A small electromagnet, a compass needle with a circular scale, a battery of at least 6 V, a variable resistance (a rheostat), an ammeter (0 - 3 A), a plug key, measuring scale, connecting wires and a peice of sand paper.

PROCEDURE

1. Note the range and least count of the given ammeter.
2. Clean connecting wires using the sand paper.
3. Using connecting wires, set an electric circuit comprising of an elctromagnet, a battery, a variable resistance (a rheostat), plug, and an ammeter such that the axis of electromagnet lies closer and parallel to one of the side edge of the table, as shown in Fig. 54.1. Initally keep the sliding contact of the rheostat around its maximum. In such a situation, the magnitude of current through the coil will be minimum on inserting the key into the plug.
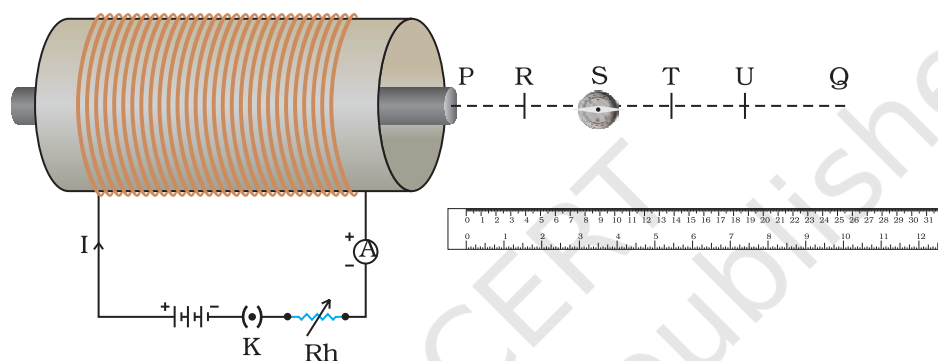
Fig. 54.1 : *The needle of the compass deflects when placed near an electromagnet*

4. From one of the end of the electromagnet, draw a line PQ of more than 20 cm on the table along the axis of the electromagnet. Mark the divisons R, S, T, U at a regular inteval of 5 cm (say) on the line PQ.
5. Place the compass needle on line PQ at point R near an end of the electromagnet such that the centre of compass coincides with the mark of point R. Rotate the compass such that its needle lies at 0°.
6. Insert the key into the plug to allow the current flow through the coil wound round the soft iron core of the electromagnet. The core will become magnetized and will produce magnetic field around it. This will produce a deflection in the compass needle. By means of changing the position of variable connector on the rheostat, adjust the value of current through the coil such that a deflection of about 30° appears in the compass needle placed at point R. Note and record the value of current through the coil and deflection in the compass needle.
7. Increase the current through the coil by changing the position of varaible on the rheostat. What happens to the compass needle? Does it deflect more now? Note and record the ammeter and compass needle readings. Repeat this step for three more values of current through

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the coil. Keep the current in the coil such that it does not produce a deflection more than 60° in the compass needle. Remove the key from the plug.

8. To change the direction of the current through the coil, interchange the connections of battery terminals. Observe the change in the deflection of the compass needle.

9. Insert the key into the plug. Again note and record the current through the coil and deflection in the compass needle placed at point R along the axis PQ of the elctromagnet. Remove the key from the plug.

10. Move the compass needle to position S. Ensure that the compass needle lies at 0°. Insert the key into the plug and observe the deflection in the compass needle. Now the compass needle is placed at a distance of 10 cm from the end P of the electromagnet. Observe and record the deflection in the compass needle when placed at different distances from the end P of the electromagnet. That is when the compass needle is placed at points T, U etc. Remove the key from the plug.

11. In this experiment, you might have drawn a few lines on the table. As a courtsey to your friends who might perform this experiment later, please clean the table.

OBSERVATIONS AND CALCULATIONS

Range of the ammeter = ____ - ____ A.

Least count of the ammeter = ____ A.

(a) Variation in the deflection in the compass needle at a point with a change in current through the coil

Position in compass needle from an end of the electromagnet = ____ cm.

Sl.No.	Current in the coil (A)	Deflection in compass needle (°) when current flows in	
		one direction	in reverse direction
1.			
2.			
3.			
4.			

(b) Variation in the deflection in the compass needle as the compass is moved from the electromagnet but the current through the coil remains the same

Current through the coil of the electromagnet = _____ A.

Sl. No.	Position of the compass needle electromagnet (cm)	Distance of the compass needle from an end of the one direction	Deflection in compass needlle (°) when current flows in reverse direction
1.	Point R	5	
2.	Point S	10	
3.	Point T	15	
4.	Point U	20	

RESULTS AND DISCUSSION

From your observations, infer the following:

- The change in the magnetic field strength of an electromagnet at a given point with the change in current through the coil of the elctromagnet.
- The change in the magnetic field strength of an electromagnet with the increase in distance from the electromagnet.
- The effect of change in the direction of electric current through the coil on the direction of magnetic field produced by the electromagnet.

PRECAUTIONS AND SOURCES OF ERROR

- The connecting wires should be thick copper wires and the insulation of their ends should be removed using the sand paper.
- The ammeter should be connected in series with the electromagnet coil such that the current enters at the positve terminal and leaves at the negative terminal of the ammeter.
- The pointer of the ammeter should be at zero mark when no current flows through the circuit. If not, then ask your teacher to correct it.
- Plug key should only be inserted in the circuit when you are recording the observations.
- There should not be any magnetic material near the electromagnet except the compass needle. Electromagnet should be kept on a wooden table.
- Size of the compass needle should not be very large.
- The amount of current through the coil of the electromagnet should be such that its magnetic field is sufficiently strong to produce an appreciable deflection in the compass needle placed at a distnce of 20 cm from an end of the electromagnet.

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NOTE FOR THE TEACHER

- In this experiment a variable resistance (a rheostat) is used to change the resistance in the circuit and thereby to change the current through the coil of the electromagnet. A rheostat may be a new instrument for the students. It is suggested to expose them to use it before they opt for this experiment. However in place of a rheostat, a resistance box may also be used in the electric circuit.

- In this experiment, a relatively higher current flows through the circuit and for this reason, it requires a high voltage battery or a high capacity battery eliminator.

- An electromagnet can be improvised in a school laboratory. Nearly forty turns of insulated thick copper wire (preferably SWG-18 or SWG-20) may be closely wrapped on a soft iron core. When an electric current is passed through the copper wire, the soft iron core gets magnetized and produces a magnetic field around it. The magnetic field produced is directly proportional to number of wrapped turns and the electric current passing through it.

QUESTIONS

- How can you make a simple electromagnet?
- Can you think of an electromagnet that is capable of producing stronger magnetic field than the magnetic field froduced by any permanent magnet?
- How does a current carrying coil of insulated copper wire wound round on a soft iron core affects a compass needle placed near to it?
- Name two ways to increase the strength of magnetic field produced by an electromagnet.
- What factors affect the strength of electromagnet?

Experiment 55

AIM

To study the force on a current-carrying straight conductor in a magnetic field and to verify that the motion of the conductor is according to Fleming's left-hand rule.

THEORY

A current carrying conductor placed in a magnetic field experiences a force (Fig. 55.1). If the direction of the field and that of current are mutually perpendicular to each other, then the force acting on the conductor will be perpendicular to both and that can be determined using the Fleming's left-hand rule (Fig. 55.2). To study the force on a current-carrying conductor, an alminium rod (AB) can be placed in a magnetic field of a horse shoe magnet, as shown in Fig. 55.1. When current establishes in the conductor (aluminium rod), it gets displaced which verifies the existance of a force on the conductor. In this experiment we shall study the dependence of force on the conductor upon the direction of the magnetic field, and upon the magnitude and direction of the current through the conductor.
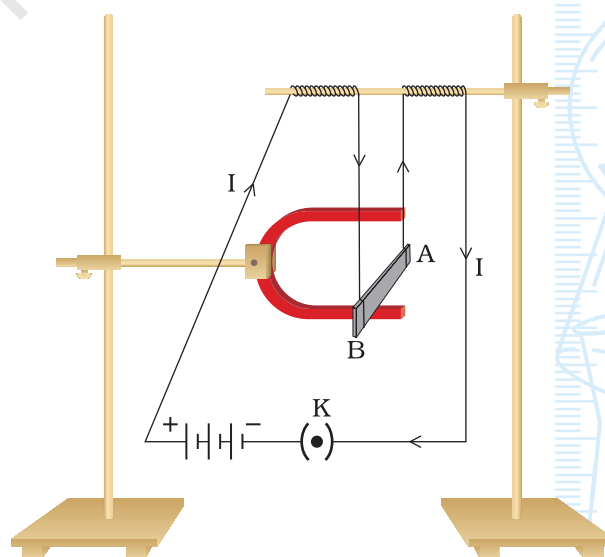
Fig. 55.1 : *A current-carrying rod, AB, experiences a force perpendicular to its length and the magnetic field*

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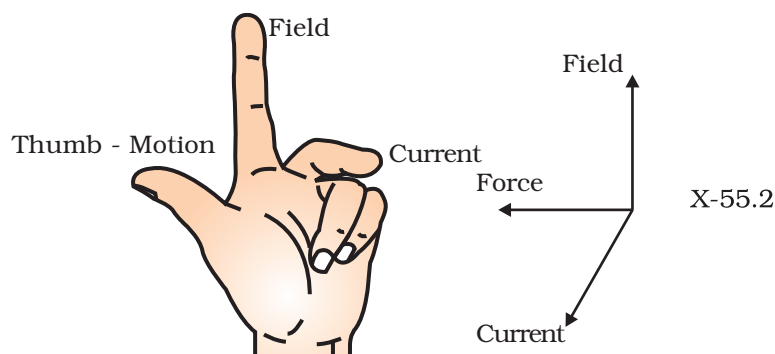
Fig. 55.2 : *Fleming's left-hand rule*

MATERIALS REQUIRED

A strong horse shoe magnet, a small aluminum rod (about 5 cm), an ammeter (0 - 3 A), two wooden stands, four dry cells (each of 1.5 V) with a cell holder (or a 6 V battery or a battery eliminator), a plug key, connecting wires, a piece of sand paper, a card boad, a graph paper, and adhesive tape,

PROCEDURE

1. Using clean connecting wires connect a conductor (a small aluminium rod) in series with dry cell holder (or a battery or a battery eliminator), an ammeter and a plug key. Do not insert the key into the plug.

2. Suspend the aluminium rod on a wooden laboratory stand such that its length AB remains horizontal. Also place a strong horse shoe magnet on another wooden laboratory stand such that its north and south poles lie in the same vertical plane.

3. Align the two laboratory stands such that the aluminium rod lies between the two poles of the magnet with the magnetic field directed upwards, as shown in Fig. 55.1. Hold a cardboard just behind the magnet and aluminium rod assembly. Fix a graph paper on it to mark the deflection in aluminium rod. For this mark the initial position of the aluminium rod on the graph paper.

4. Connect the aluminum rod in series with one cell (or set the battery eliminator on 2 V terminals) and insert the key into the plug to allow the current flow through the conductor. (Let the current flow through point B to A in the conductor.) Note and record the ammeter reading.

5. Do you see any displacement in the conductor? In which direction it moves? Does it move towards the left? Examine that this displacement is in accordance with the fleming's left-hand rule. For this stretch the thumb, fore finger and middle finger of your left hand such that they

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are mutually perpenducular (Fig. 55.2). Adjust your fore finger in such a way that it points in the direction of magnetic field (upwards), and the middle finger points in the direction of current (B to A) then your thumb must point towards the left direction. Measure the displacement of the aluminium rod AB, using the graph paper placed behind (step 3).

6. Reverse the direction of electric current passing through the aluminum rod by interchanging the connections of cell (or battery or battery eliminator) and ammeter. (Always ensure that the poistive terminal of ammeter is connected with the positive terminal.) Observe the direction of displacement of conductor. Does it moves in opposite direction? Mark and record it.

7. Repeat steps 4 to 6 for different values of current through the conductor. Use two cell dry cells for 3 V supply, three cells for 4.5 V supply and four cells for 6 V supply. (Change the battery eliminator settings accordingly if a battery eliminator is used.) Note and record the current through the rod AB, its displacemnet (for both the directions of current).

OBSERVATIONS AND CALCULATIONS

Sl. No.	No. of cells cells used	Voltage of supply (V)	Current through the rod AB	Displacement of aluminium rod (mm) when current flows through it along	
				BA (deflection towards left)	AB (deflection towards right)
1.	1		1.5		
2.	2		3.0		
3.	3		4.5		
4.	4		6.0		

RESULTS AND DISCUSSION

From your observations, infer the following:

- On passing current through a straight conductor (aluminium rod) kept in a magnetic field, the conductor gets displaced.
- The displacement of the conductor increases as the current increases in the conductor.
- The direction of displacement of the conductor rod changes with the change in the direction of current through it.
- The displacement of aluminium rod is in accordance with Fleming's left-hand rule.

PRECAUTIONS

- Clean the ends of the connecting wire using a sand paper to remove the insulating layer from them.
- Aluminium rod (AB) should be suspended in such a way that it should not touch the horse shoe magnet.
- Horse shoe magnet should be fixed a using wooden stand.
- There should not be any other magnetic material near the experimental set-up.
- Plug key should be inserted in the circuit only at the time of recording the observations.

NOTE FOR THE TEACHER

- If a strong horse shoe magnet is not available then a U-shaped magnet can be improvised with the help of two strong bar magnets (Fig. 55.3).

Fig. 55.3 : Improvising a U-shaped magnet

- Conductor through which current is passed, should be light in mass so that displacement of the condutor can be noticed easily.
- Fix the graph paper behind the assembly in such a manner that the displacement of the conductor can be measured in both (left and right) directions.
- This method can also be used to show that for a given magnitude of the current, the displacement of the rod is largest (or the magnitude of the force is the highest) when the direction of current is at right angles to the direction of the magnetic field.

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QUESTIONS

- Why does the aluminum rod get displaced in this experiment ?
- List the devices used in our everyday life that use current-carrying conductors.
- What do you expect if the position of horseshoe magnet and the aluminium rod are interchanged in this experiment.

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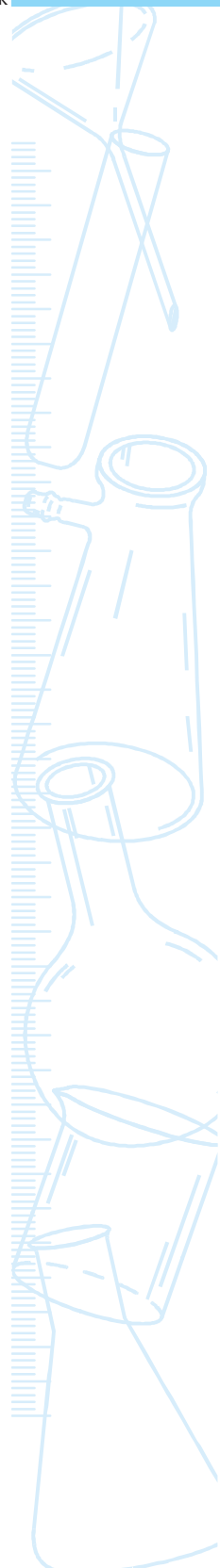
Experiment **56**

# AIM

To study the phenomenon of electromagnetic induction.

THEORY

The phenomenon of electromagnetic induction is the existence of an induced current in a circuit (such as a coil) placed in a region where the magnetic field changes with time. The magnetic field may change due to a relative motion between the coil and a magnet placed near to the coil. We know that a current-carrying conductor also produces magnetic field that changes with a change in the current flowing through it. Thus if a coil is placed near to a current-carrying conductor, an induced current in the coil may set-up due to a change in the current through the current-carrying conductor. In this experiment we first see the effect of moving a magnet in a coil connected with a galvanometer (Fig. 56.1). We will then see the effect of varying current in a coil (coil-1) on another coil (coil-2) connected with a galvanometer (Fig. 56.2).
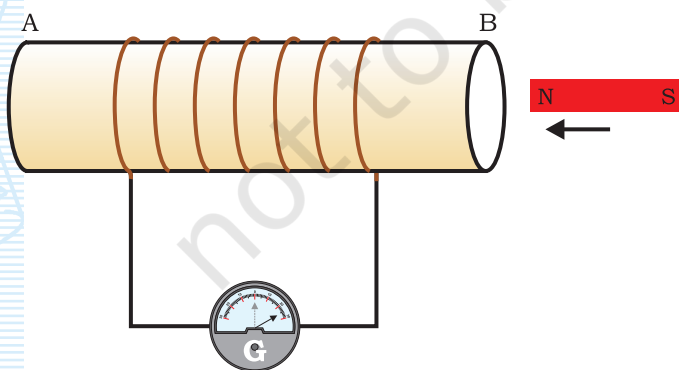
Fig. 56.1 : *Moving a magnet towards a coil sets up a current in the coil circuit, as indicated by deflection in the galvanometer needle*

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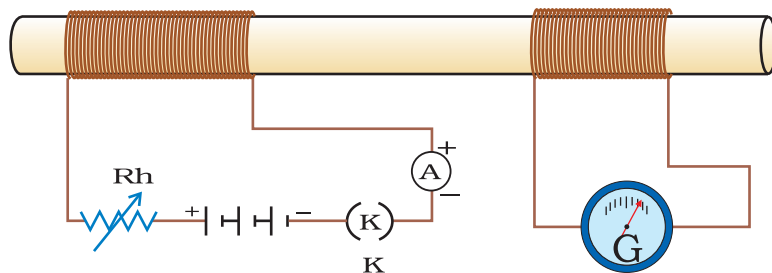
Fig. 56.2 : *Current is induced in coil-2 when current in coil-1 is changed*

MATERIALS REQUIRED

Two coils of copper wire each having about 50 turns, a rheostat (variable resistor), an ammeter (0 - 3 A), a galvanometer, a strong bar magnet, a plug key, connecting wires, and a piece of sand paper.

PROCEDURE

A. Existance of induced current in a coil due to the relative motion between a coil and magnet

1. Take a coil AB and connect it with a galvanometer as shown in Fig. 56.1.

2. Take a strong bar magnet and move its north pole (or south pole) towards an end (say B) of the coil. Observe the position of needle of galvanometer. Is there any deflection in it? There is a momentary deflection in the galvanometer needle in one direction (say in right direction). What does this indicate? This indicates the presence of a current in the coil AB.

3. Stop moving the bar magnet. What do you observe now? Does the galvanometer shows any reading? No. The deflection of the galvanometer becomes zero when the motion of the bar magnet stops. What does it mean?

4. Now withdraw the north pole of the magnet away from the coil and observe the deflection in galvanometer. The galvanometer needle now deflects in the opposite side (that is in left side), depicting that the current is now set up in the direction opposite to the first.

5. Move South Pole of the magnet towards the end B of the coil and observe the deflection in the galvanometer needle.

6. Place the magnet stationary at a point near to the coil retaining its north pole towards the end B of the coil and observe it. The galvanometer needle deflects towards the right when the coil is moved towards the north pole of the magnet. Similarly, the needle moves towards the left when the coil is moved away. Deflection of galvanometer drops to zero when coil is kept stationary.

7. Finally keep the coil and the magnet both stationery and observe the deflection. There is no deflection in the galvanometer. It is thus clear that motion of a magnet with respect to the coil produces an induced potential difference which sets up an induced electric current in the circuit as has been noticed by the deflection of galvanometer in above steps. Record your observations.

B. Existance of induced current in a coil due to a change in the current through another coil placed close to it

8. Connect a coil (coil-1, say) of copper wire with a source (a cell or a battery), through a rheostat, an ammeter and a plug key, as shown in Fig. 56.2. Use clean connecting wires to make the circuit.

9. Bring another coil (coil-2) connected with a galvanometer close to the coil-1 circuit.

10. Plug the key and allow a current to flow through coil-1. What do you observe? Does the galvanometer needle connected with coil-2 deflects. Yes it momentarily deflects. It stops at the zero mark as soon as the current in coil-1 becomes steady. (Adjust the variable connector of the rheostat to allow an appreciable current to flow through the coil-1. Note that a rheostat is basically a resistor of variable resistance. It is connected in series in a circuit to change the resistance in the circuit.)

11. Change the current through coil-1, by moving the variable slider on the rheostat coil. What do you observe? Do you see that the galvanometer connected with coil-2, shows deflection in one direction when current in coil-1 circuit increases while the deflection in galvanometer needle reverses when the current in coil-1 circuit decreases.

12. Record your observations in the observation table.

OBSERVATIONS AND CALCULATIONS Ⓐ

(a) Existance of induced current in a coil due to the relative motion between a coil and magnet (Fig. 56.1)

Sl. No.	Activity	Deflection in the needle of the galvanometer (right/left/no deflection)	Inference
1.	Coil stationary; N-pole of the bar magnet magnet moving toawrds the coil.		
2.	Coil stationary; N-pole of the bar magnet magnet moving away the coil.		
3.	Coil stationary; S-pole of the bar magnet magnet moving toawrds the coil.		
4.	Coil stationary; S-pole of the bar magnet magnet moving away the coil.		
5.	Bar magnet stationary with its N-pole towards the coil; Coil moving towards the magnet.		
6.	Bar magnet stationary with its N-pole towards the coil; Coil moving away the magnet.		
7.	Bar magnet stationary with its S-pole towards the coil; Coil moving towards the magnet.		
8.	Bar magnet stationary with its S-pole towards the coil; Coil moving away the magnet.		
9.	Both coil and magnet stationary		

(b) Existance of induced current in a coil (coil-2) due to a change in the current through another coil (Coil-1) placed close to it (Fig. 56.2)

Sl. No.	Activity	Deflection in the needle of the galvanometer (right/left/no deflection)	Inference
1.	No current through the coil-1.		
2.	Current increasing in coil-1.		
3.	Current decreasing in coil-2.		

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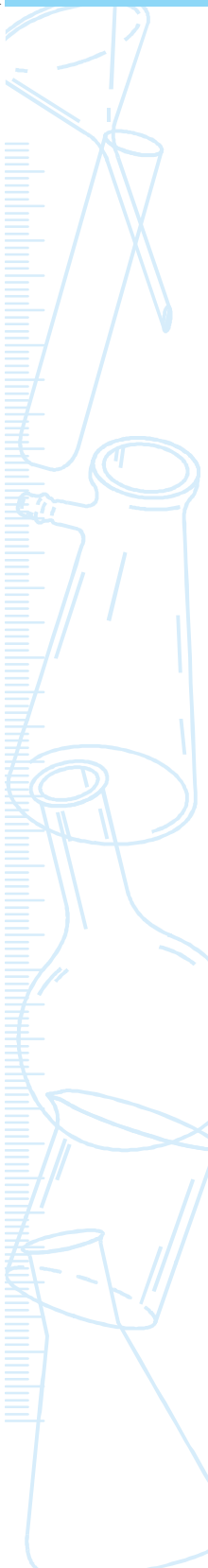
RESULTS AND DISCUSSION

Write the inferences of the activities in observation table and conclude that the phenomenon of electromagnetic induction is the production of induced current in a coil placed in a region where the magnetic field changes with time. Also comment on the ways you can induce a current in a circuit that does not have any source of electricity.

PRECAUTIONS

- Clean the ends of the connecting wire using a sand paper to remove the insulating layer from them.
- Bar magnet should move (inside or outside the coil) such that it does not touch the coil.
- Wrapping of copper wire of coils should be uniform.
- There should not be any other magnetic material near the experimental set-up.

NOTE FOR THE TEACHER

- Copper coils can be prepared by uniformly wrapping the insulated copper wire either on a cylindrical plastic or a porclein pipe. The wrapping of the wire must be such that the direction of current through every ring must be in the same direction.

QUESTIONS

- What do you conclude if no deflection in the galvanometer is observed in this experiment?
- Explain different ways to induce current in a conducting coil.
- A coil of insulated copper wire is connected to a galvanometer. What will happen if a bar magnet is (i) inserted into the coil, (ii) pulled out from the coil, and (iii) held stationary inside the coil.
- Two current-carrying coils 1 and 2 are placed closed to each other. If the current in the coil 1 is changed, will there be some induced current in the coil 2? Why?
- Name the devices which are based on the phenomenon of electromagnetic induction.

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