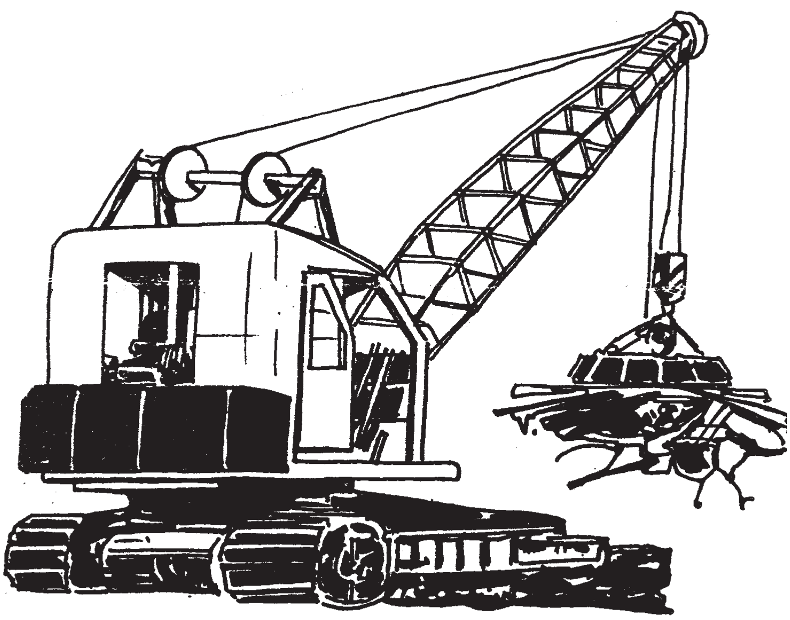
10 ELECTROMAGNETISM



Raju and Anees were discussing a scene they had seen in a steel factory while they were on a study tour.

Raju told Anees that the heap of old iron pieces were transferred to the furnace by nothing other than a magnet fitted on a crane. "How can such a huge magnetic force get created and cancelled?" exclaimed Anees.

★ What is the role of electricity in such situations?

Let's do a simple experiment.

Magnetic field around a straight conductor carrying current

Place a pivoted magnetic needle on a table. Hold a straight copper wire just above the magnetic needle and parallel to it. Pass electric current from a battery through the wire for a short time.

What have you observed?

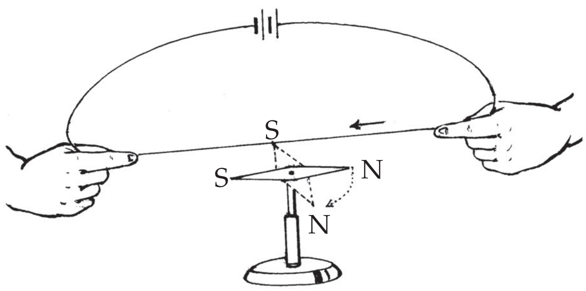


Fig. 10.1

★ Did the needle deflect?

\- -

★ What happened when you stopped the electric current?

\- -

★ What happens to the deflection when the current is reversed?

\- -

★ What is the reason for the deflection of the magnetic needle?

\- -

Haven't you understood that a magnetic field is formed around a straight conductor carrying current?

Can this magnetic field be depicted?

Let's do an experiment

Make a hole on a smooth cardboard and support it horizontally on two wooden plugs. Insert a straight copper wire perpendicular to the board through the hole and connect its ends to a battery.

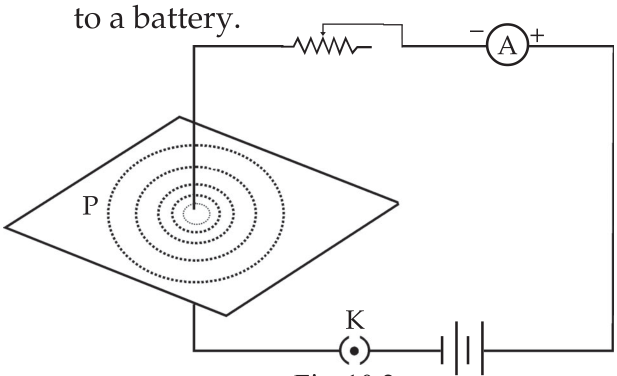


Fig. 10.2

Scatter fine iron filings on the cardboard. Tap the card gently. What do you see? Observe the distribution of iron filings.

- ★ Is the distribution of iron filings uniform in all the circles?

  -

- ★ What difference did you notice as the circles widen away from the wire?

  -

- ★ What is the conclusion that you have arrived at from this?

  -

Draw in your science diary the pattern formed by the iron filings.

- ★ What is the shape of the pattern you got? Which is their centre?

Repeat the experiment scattering again iron filings on the cardboard. Now adjust the rheostat to increase the current in the circuit. (Remember that more than 2A current is to be passed to get better results).

- ★ Did any change occur in the distribution of the iron filings? What was the change observed?

What is the inference you have arrived at from this experiment? Record in the science diary.

Let's find out the direction of the magnetic field

Is it possible to find out the direction of the magnetic field around a straight conductor? Do an activity.

Remove the iron filings of the previous experiment and place a magnetic needle on the card board. Now pass electric current through the conductor. Note down the direction of current.

- ★ Does the direction of the magnetic needle change when current is passed?

  -

Mark on the paper the position of the north pole of the magnetic needle. Shift it so that now the south pole of the magnetic needle is at the marked point. Mark again the position of the north pole and continue the activity.

> **Direction of electric current**
>
> *Electric current flows from the positive terminal of a battery to the negative terminal.*

Keep the magnetic needle at various points on the cardboard and repeat the experiment.

Remove the magnetic needle and draw

a curve joining the successive points you have marked.

★ What is the shape of the curves obtained?

The direction of the magnetic line of force at a point in a magnetic field is the direction of motion of a free isolated north pole placed at that point. The direction of line of force is the direction of the magnetic field at that point.

We have seen that a magnetic field can be depicted by lines of force with directions marked.

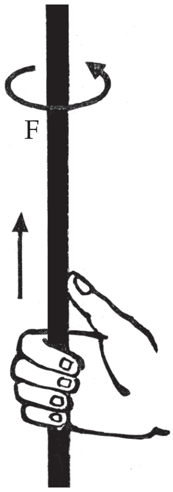


Fig. 10.3

Repeat the experiment by reversing the current.

Compare the directions of the current and the magnetic field, in each case.

Is there any relationship between the direction of the current and that of the resulting magnetic field?

Note your findings in the science diary.

This relationship can be found out by using the thumb and other fingers of your right hand.

Hold the conductor in the right hand in such a way that the thumb indicates the direction of the current. Note the direction in which the fingers curl. Is there any similarity between this direction and the direction of the curve obtained by the successive position of the north pole of the compass needle placed in the magnetic field?

Imagine that you are grasping the current carrying conductor in your right hand such that the thumb indicates the direction of the current, then the direction in which the ends of other fingers point indicates the direction of the magnetic field. This is the right hand rule.

You have now understood what the direction of the magnetic field formed around a straight conductor carrying current will be.

What is the direction of the magnetic field when a current is passed through a circular coil?

The magnetic field around a circular coil

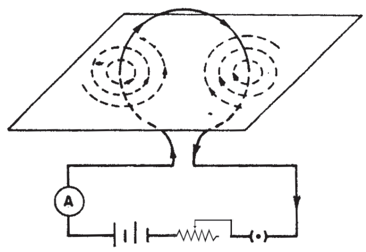


Fig. 10.4

Pass a copper wire through two holes in a cardboard and bend it in the form of a circle as shown in the figure.

Connect it to the terminals of a battery through a switch.

Scatter iron filings on the cardboard, around the coil. Switch on the current and gently tap the cardboard

★ What peculiarity do you observe in the distribution of the iron filings when compared to that around the straight conductor?

★ How are the iron filings distributed?

★ What conclusion do you arrive at from this?

★ What happens if the number of turns of the coil is increased?

- -

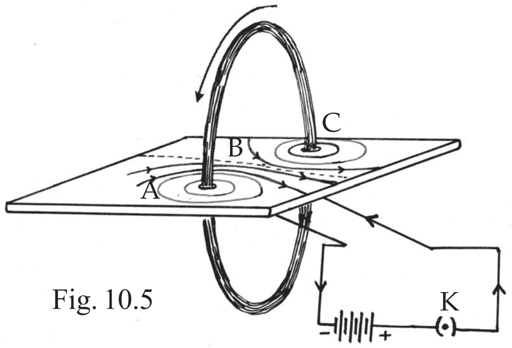


Fig. 10.5

As in the above figure, mark points A and C on the cardboard outside the circular coil and B inside. All the points should be in a straight line. Keep a magnetic needle on each of these points and switch on the current. What do you observe?

Is the direction of the north pole of the magnetic needle at A, B and C the same?

Draw a line on the cardboard through B perpendicular to the line ABC. Keep magnetic needles on various points on this line and repeat this experiment. Is there any variation in the direction of the magnetic needle? If so, how are they?

- -

★ What conclusion do you arrive at from this? Record it.

- -

Make two turns of the same wire in circles not touching each other and repeat the experiment.

★ What is the direction of the magnetic field formed around each coil?

- -

★ And inside the coils?

- -

The magnetic field around a solenoid

Keep two semi cylindrical PVC pipes one above and the other below a cardboard. Draw parallel lines on the cardboard along the edges of the cylinder. Make holes in the cardboard along this line at intervals of 0.5 cm.

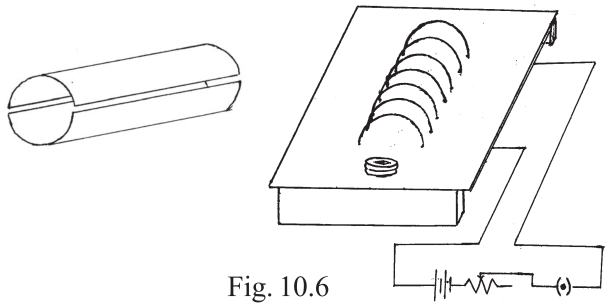


Fig. 10.6

A long insulated conducting wire wound in the form of a helix is a solenoid.

Make a solenoid as in fig. 10.6 by winding the wire through the holes. Remove the pipes. The solenoid for doing the experiment is ready.

Connect the ends of the solenoid to a circuit containing a rheostat, a switch and a battery. Switch on the circuit.

Move a magnetic compass box both inside and outside the solenoid and mark the points indicated by the north pole of the needle.

Join these points and draw the magnetic lines of force with the direction marked.

★ What is the direction of the magnetic field inside the solenoid?

- -

★ What is the polarity of the magnetic pole formed at each free end of the solenoid?

- -

★ Which is the end of the solenoid where the north pole of the magnetic needle is attracted?

____

★ If so, what will be the polarity at this end of the solenoid?

____

★ And at the other end of the solenoid?

____

★ From which terminal of the battery to which does the current flow through the solenoid?

____

Try to find the direction of the current at the end of the solenoid connected to the positive terminal of the battery. Compare this with the direction of motion of the hands of a clock.

★ If it is clockwise, what is the polarity formed at this end?

____

★ And if it is anti clockwise?

____

Repeat the experiment by reversing the current through the solenoid in the circuit.

★ What are the changes observed in the magnetic polarity formed at the free ends of the solenoid?

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What is the conclusion you arrive at regarding the magnetic polarity at the ends of the solenoid and the direction of the current through the solenoid at these ends? Compare it with fig. 10.8

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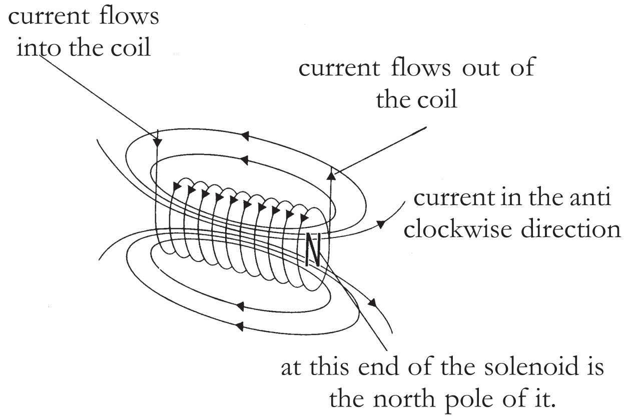

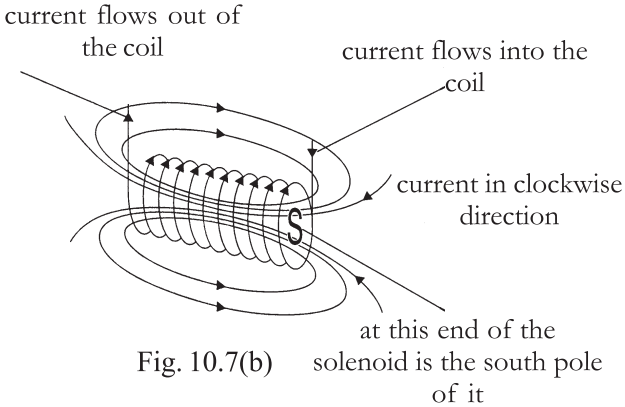

Fig. 10.7(b)

An easy way to find out the magnetic polarity at the ends of a solenoid depending on the direction of current in it.

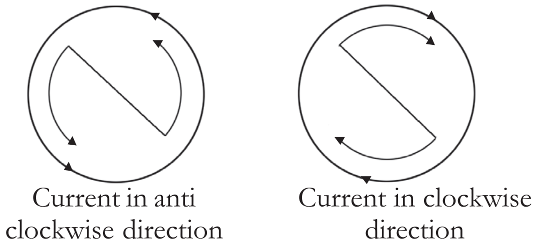

Fig. 10.8

The figures below show the magnetic field of a bar magnet and that of a solenoid carrying current.

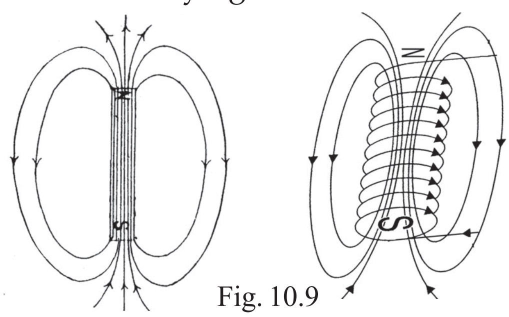

Fig. 10.9

Compare them. What conclusion do you arrive at?

We have found that a solenoid carrying current behaves like a bar magnet. Let's now look into the methods for enhancing the strength of such a magnet.

Make a solenoid by winding 25 turns of insulated copper wire on a small piece of PVC pipe. Keep a magnetic compass needle at one of the free ends of this solenoid. Observe the deflection of the magnetic needle by passing current through the solenoid.

★ Record your findings.

- -

Repeat the experiment by increasing the number of turns.

Record your observations.

★ When did the magnetic needle deflect more?

- -

Repeat the experiment by inserting pieces of iron binding wires/soft iron core into the solenoid.

★ What change do you observe in the deflection of the magnetic needle?

- -

★ What happens if you increase the number of iron binding wires in the solenoid?

- -

★ Compare the findings.

- -

Repeat the experiment by varying the current in the solenoid.

★ What is the change that takes place in the deflection of the magnetic needle?

- -

From these experiments, we have found out the factors that influence the magnetic field formed around a solenoid.

We have already learned that when a solenoid is used like this, it functions like an electromagnet.

★ If so, what are the methods to enhance the strength of an electro magnet?

-
- Increase the area of cross section of the iron core.

Along with Anees, you too must have understood by now that electro magnets are used in cranes. These are capable of lifting several tons of iron and steel and that their strength can be enhanced through various methods.

You have learnt how to make electro magnets. What are the situations in which electromagnets are used?

- Electric bell
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Examine the parts of an electric bell shown in the figure. Discuss how it works when it is switched on.

Make an electric bell and exhibit it.

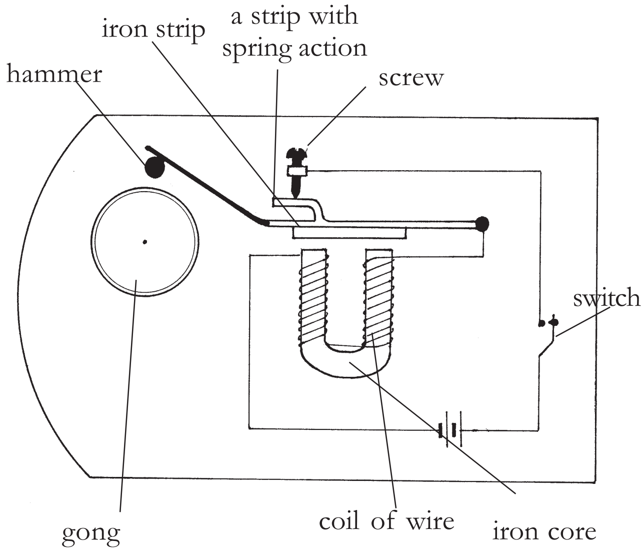

Fig. 10.10