ELECTRICITY-3 12

The magnetic effects of electricity

In classes 6 and 7, you did some experiments with electricity and discovered some exciting things. In class 6, you also did interesting experiments with magnets. In this chapter, you will see that there is a close relationship between electricity and magnetism. Does that surprise you? It will be difficult to fully understand this relationship in class 8. However, we can get an idea of this relationship through experiments.

That a magnetic effect is produced by electricity was discovered as early as 1819 in Denmark, by a scientist named Oersted. We ourselves shall do the experiment here from which he discovered this fact. But wait a minute. Before beginning the experiment, we have to understand one thing, when we make a circuit by connecting wires to cells, the electrical current will have a direction.

The direction of electrical current in a circuit

Last year when you did the experiment on copper plating (Chapter "Electricity-2", experiment-8), we saw that when we connect a copper wire to the positive end and a carbon rod to the negative end of a cell, copper starts to accumulate on the carbon rod. By reversing the circuit, that is, by connecting the copper wire to the negative end and the carbon rod to the positive end, the copper starts accumulating back on the copper wire. We can say that in such a circuit, the copper always flows from the positive end to the negative end. Scientists have come to call the direction of the flow of copper, the direction of electric flow. Therefore, we can say that in every circuit, the current flows from the positive end to the negative end of the cell. In Figure-1, the direction of the current is shown by arrows.

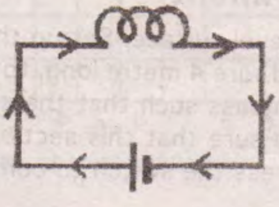

Figure-1

Copy the following circuits in your note book and show the direction of current in each circuit with arrows. (1)

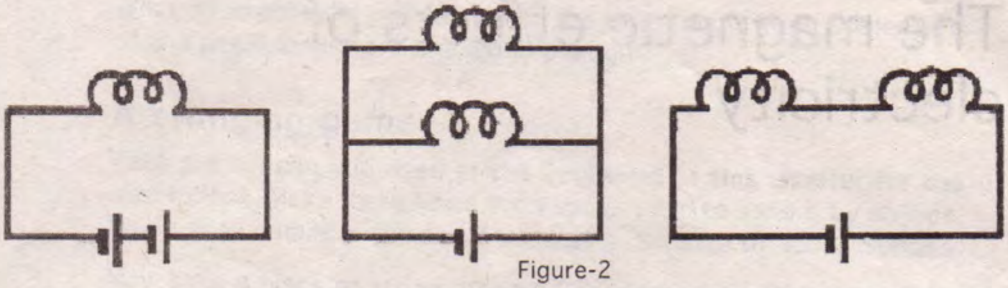

Figure-2

Now we shall do the experiment which Oersted had done.

Testing the circuit

From the experiments with electricity done by you so far, you know that a bulb will only light up if the circuit is complete. In a circuit without a bulb, how can you tell if the circuit is complete or not? You must have seen employees of the electricity department testing circuits using a bulb with two wires attached to it. You too can test all your circuits by putting a bulb in a bulb holder with two wires. To do this, connect the wires of your bulb holder to the two nails of the switch, as shown in Figure-3, and press the switch. If the bulb lights up, your circuit is correctly set up. If it does not, something is wrong somewhere in your circuit. Look for the problem and fix it. Test the circuit again to see if it is complete.

After checking that the circuit is correct, remove the test bulb holder with its wires, and proceed with your experiment.

But beware

1. Your bulb is only for testing circuits with battery cells. **Never ever attempt to test any electrical connection, with this, at home, school, in the fields or anywhere else. This is extremely dangerous.**

2. If your cell is weak, the test bulb would not light up even if the circuit is correct. In such a situation, change the cell and test the circuit again.

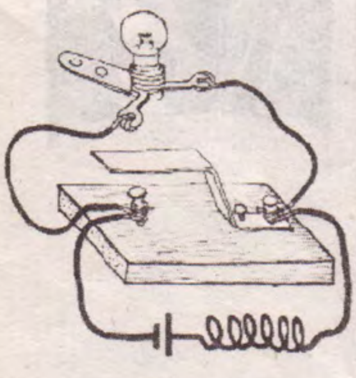

Figure-3

Experiment-1

Oersted's experiment

Place a compass on a level surface. Set up the circuit shown in figure-4. Use an enamelled wire 4 metre long, to set up this circuit. Put the wire above the compass such that the section p-q of the wire runs north-south. Make sure that this section of wire is right over the compass needle. Press the switch to complete the circuit.

Did this have any effect on the direction of the needle? If it deflected, in which direction did the north pole move? (2)

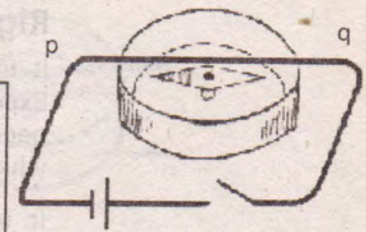

Figure-4

> In your kit there are two pieces of enamelled copper wire - one 4 metre long and the other 6 metre long. The 4 metre long wire is for Experiment-2, Experiment-3 and the train signal. The 6 metre long wire is for Experiment-4 and the electric motor. You will need long wire for other experiments. Therefore, do not cut the wires. Cut them into smaller pieces only if the experimental instructions tell you to do so.

While noting your observations, keep in mind that we have assumed that electric current flows from the positive end of the cell to the negative end.

Reverse the cell and repeat the experiment.

In this experiment, what was the direction of the electric current? If the needle moved, which direction did the north pole turn? (3)

Now place the compass above the p-q section of wire.

Find out the direction in which the north pole turns, when the electric current -

(a) flows from north to south.

(b) flows from south to north. (4)

Make a table like the one shown below and record your observations in it.

Table-1

Direction of electric curent inwire p-q	Whether the p-q wire is above or below the compass	Direction of movement of the nortrh pole of the needle
North to South	above	
South to North	above	
North to South	below	
South to North	below	

Till now, you had seen the needle of a compass move only when a magnet was brought near it. However, in this experiment, you saw that a wire in which there is an electric current also causes the same effect.

What conclusions can you draw from this? (5)

Does a wire start to act like a magnet as soon as electricity flows through it? (6)

Right Hand Rule

It is clear now that an electric current has a magnetic effect. In Experiment-1, we saw that an electric current causes a magnetic needle to deflect. With the help of our right hand, we can find out in which direction it would deflect in a particular situation.

In order to do this, place your right hand as shown in Figure-5 so that -

(a) Your fingers point in the direction of flow of current, and

(b) The palm of your hand faces the compass and the wire is between the compass and your palm.

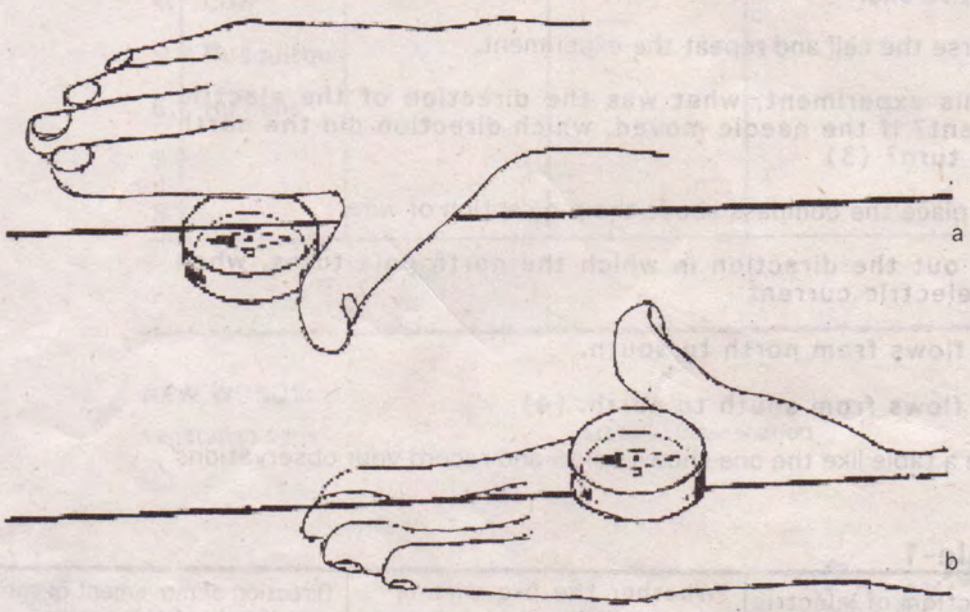

Figure-5

When you hold your right hand like this, your thumb points the direction in which the north pole of the needle turns. Use your observations to check this rule.

Experiment-2

Set up experiment-1 again. Fold wire section p-q in the middle to double it. Put the folded wire north-south.

Find out if electric current has any effect on the direction of the needle when -

(a) the folded wire is above the compass (Figure-6 a),

(b) the folded wire is under the compass (Figure-6 b),

(c) the compass is placed between the two folds of the wire (Figure-6 c). (7)

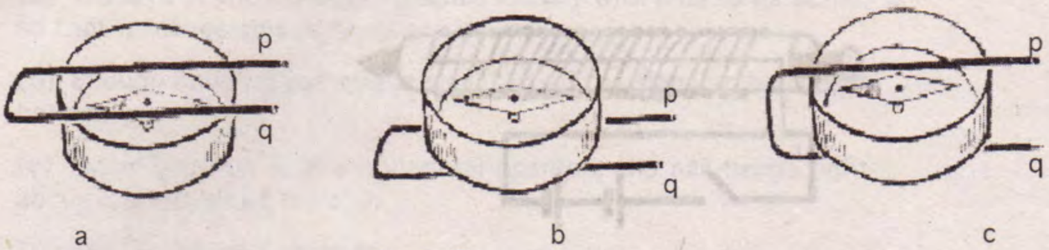

Figure-6

In your note book, draw all the three diagrams and show the direction of current in wire section p-q. (8)

Discuss with your teacher and explain the observations of this experiment in your own words, using the Right Hand Rule just learnt. (9)

Take a look at the situation of fig-6c once again. Right now the wire p-q is wound round the compass only once. If we wind the wire around the compass to make two and then three turns, will the deflection of the needle increase or decrease. Find out by doing it.

If we keep increasing the turns of wire around the compass, what would be the maximum deflection of the needle? (10)

Think about it. Do an experiment by progressively increasing the number of turns to verify your hunch.

Experiment-3

Make an electro-magnet

Cut out a piece of paper 7-8 cms wide and 20 cms long and apply glue to one of its sides. Roll the paper around a pencil so that the side with the glue on it does not touch the pencil and make a 7-8 cm long tube. Carefully remove the pencil and set it aside until the glue has dried. Now take the 4 m enamelled copper wire. Starting 10 cms from one of its ends, wind the wire around the paper tube as shown in Figures-7a and b to make a coil.

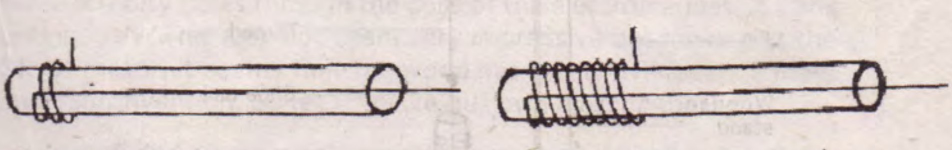

Figure-7

You should be able to wind the wire around the tube about 100 times. Make sure that the turns, though closely packed, do not overlap. Insert a long nail in the tube.

Connect this coil to the circuit shown in Figure-7 c. Throw some pins

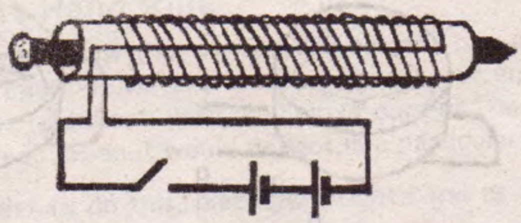

Figure-7(C)

around the coil and press the switch to complete the circuit.

Do the pins get attracted to the ends of the coil? (11)
What happens when you release the switch? (12)

Interesting, is it not? In class-6, you studied the magnetic field of a bar magnet. Now, if an electric coil produces a magnetic effect, it is clear that it too has a magnetic field. To study the magnetic field of the electromagnet, place the coil along with the nail in north-south direction. Place a piece of card sheet over this and sprinkle some fine iron filings on it. Complete the circuit and tap the card sheet three or four times. To compare, repeat this experiment with a bar magnet.

Compare the magnetic fields of an electromagnet with a bar magnet and illustrate your observations with a drawing. (13)
Discuss the results of all the experiments you have done so far with your teacher. Find out what are the similarities between a magnet produced due to electricity and an ordinary bar magnet. Write the answer in your own words. (14)

Make a train signal

If you want, you can use your electromagnet to build your own electric train signal as shown in Figure-8. To do this, take care that :

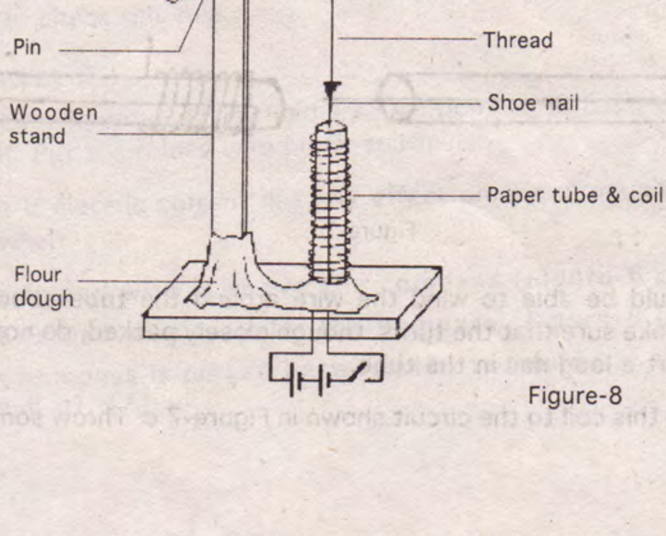

Figure-8

(a) the arm of the signal is attached loosely with pins to its stand, so that it moves smoothly up and down.

(b) Enough dough is put on the small arm of the signal to balance it horizontally.

(c) when the arm is in a horizontal position, the nail hangs right above the mouth of the coil.

This signal can only go down.

Design and build a signal that can go up. Note the method of construction in your note book. (15)

Experiment-4

An electric swing

Take a 60 cm. enamelled copper wire. Clean both ends of the wire with sandpaper. Hammer two small nails on the edge of a table 5 cms from each other. Wrap the wire around the nails as shown in Figure-9 so that you have a sort of swing hanging down.

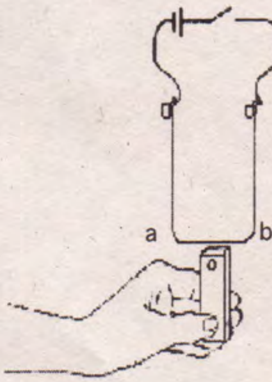

Figure-9

Make a circuit as shown in the figure. Hold any one pole of a bar magnet right under wire section a-b. The magnet should be close to the wire but not touching it.

Press the switch and see what effect this has on the swing. (16)
Reverse the cell in the circuit. What happens when you press the switch now? (17)
In the same way, repeat the experiment holding the other pole of the bar magnet under the swing and see what happens. (18)

Make your own electric motor

The electric motor makes use of the effect of magnetic fields of two fixed magnets on an electromagnet. The effect is such that whenever electricity flows through the coils of the electromagnet, it spins continuously. This may not seem very impressive but looking at the uses of motor, it seems that the world has hardly ever seen a more important invention. So let us make our own electric motor.

Take a cork and pierce a hole exactly through the middle of it with a needle [Figure-10a]. If you can not obtain a cork, a corn cob will do, but use just a 4-5 cm piece of it. To see if the needle has gone exactly through the middle of the cork, rest the needle horizontally on your fingers and see if the cork turns easily on its axis or not. If a certain part of the cork is always at the bottom when it stops, remove the needle and stick it again properly.

Figure-10 a

With a razor blade, cut a 1 cm wide groove along the diameter of both the flat ends of the cork. On the broader end of the cork, stick in two pins on either side of the needle at a distance of about 1 cm from the needle (Figure-10b). They should stick out at least 1 cm from the cork.

Figure-10 b

Take the remaining 6 metre wire from your kit and clean one end well with sandpaper. Wind the end you have cleaned around one of the pins. Take care not to let the cleaned part touch the needle (Figure-10c).

Figure-10 c

In order to make the coil of the motor, start winding the wire in the grooves on the cork. The number of coils on each side of the needle should be about equal. In this way, wind the entire length of the wire (about 50 turns). After cleaning the other end of the wire, fix it tightly on the second pin (Figure-10d). Attach your bulb circuit to the two pins and test whether your coil is correctly made.

Now insert four pins on a wooden board as shown in Figure-10e.

Figure-10d

Rest your coil on these pins and make sure that the cork rotates evenly on its axis. If necessary, adjust the pins a little so that the coil is horizontal and rotates freely.

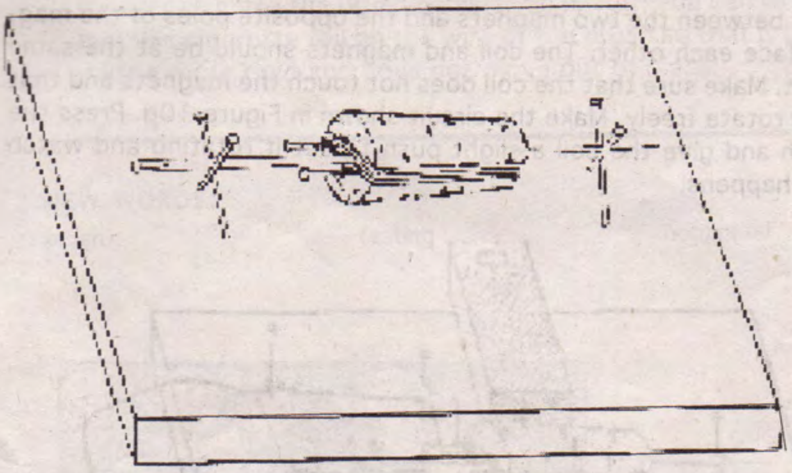

Figure10-e

Stick two more pins (p & q) on the board. These pins should be on the same side and in line with the pins in the cork. In front of pins p and q, hammer two more pins (r & s) (Figure-10f). Take the 60 cm copper wire from experiment-4 and cut it in two pieces. Clean the ends of these pieces well. First tightly roll one end of one wire around pin r. Then roll this wire around pin p to make a loop in the opposite direction. After rolling it around pin p, bend the wire so that it stands vertically and the cleaned end touches the pin in the cork. Fix the other half of wire on the other side in the same way (Figure-10f).

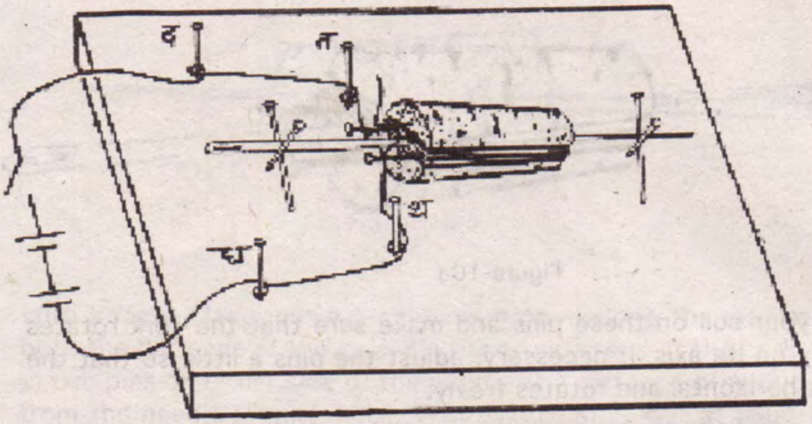

Figure-10f

Take two bar magnets. Place them on the wooden board so that the coil is between the two magnets and the opposite poles of the magnets face each other. The coil and magnets should be at the same height. Make sure that the coil does not touch the magnets and that it can rotate freely. Make the circuit shown in Figure-10g. Press the switch and give the coil a slight push to set it rotating and watch what happens.

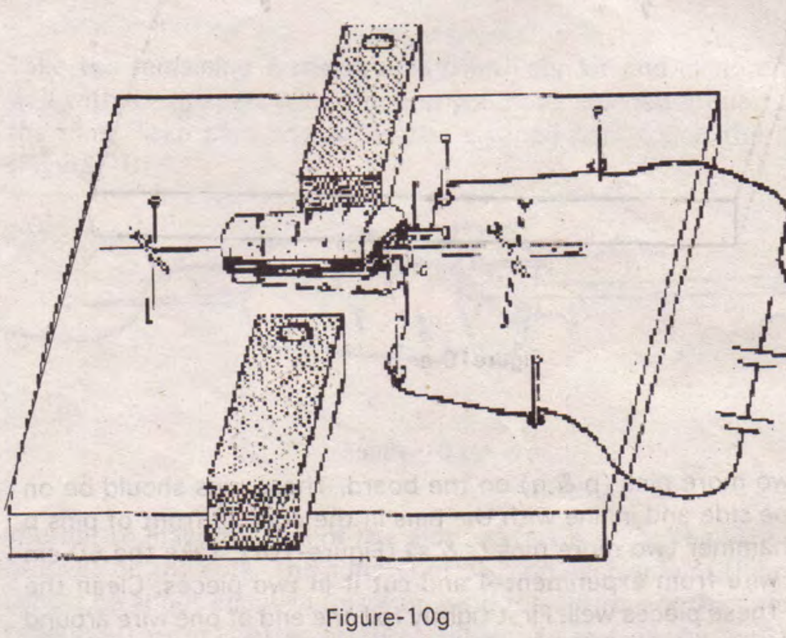

Figure-10g

Some precautions

Making an electric motor requires a bit of effort. If your motor does not run the first time, do not lose heart. A few hints are given below. Test the motor again and do not stop until the motor starts:

1. The coil should be able to turn freely on the pins. Rotate it with your fingers and check. If it does not rotate easily, set up the pins again.

2. The part of the circuit (wires) which touches the pin of the coil is called the brush. Usually, this is where the problem comes. The brushes should touch the pins but should not press too tightly against them, because then the coil will not be able to rotate freely.

   It is necessary to completely remove the enamel from the brush. When the brushes and pins are touching each other as in Figure-10g, attach a bulb to the switch of the circuit and see if it lights up. If the lamp does not light up, this means that either the brush and pin connection is not correct, or there is a problem in the connection of the pin with the wire in the coil. Check this again. Also test this by rotating the coil by 180°.

3. In order to make the brush connection better, you can wrap some metallic cigarette foil on the wire of the brush so that it becomes a little more rigid and does not move out of place.

NEW WORDS:

brush testing horizontal