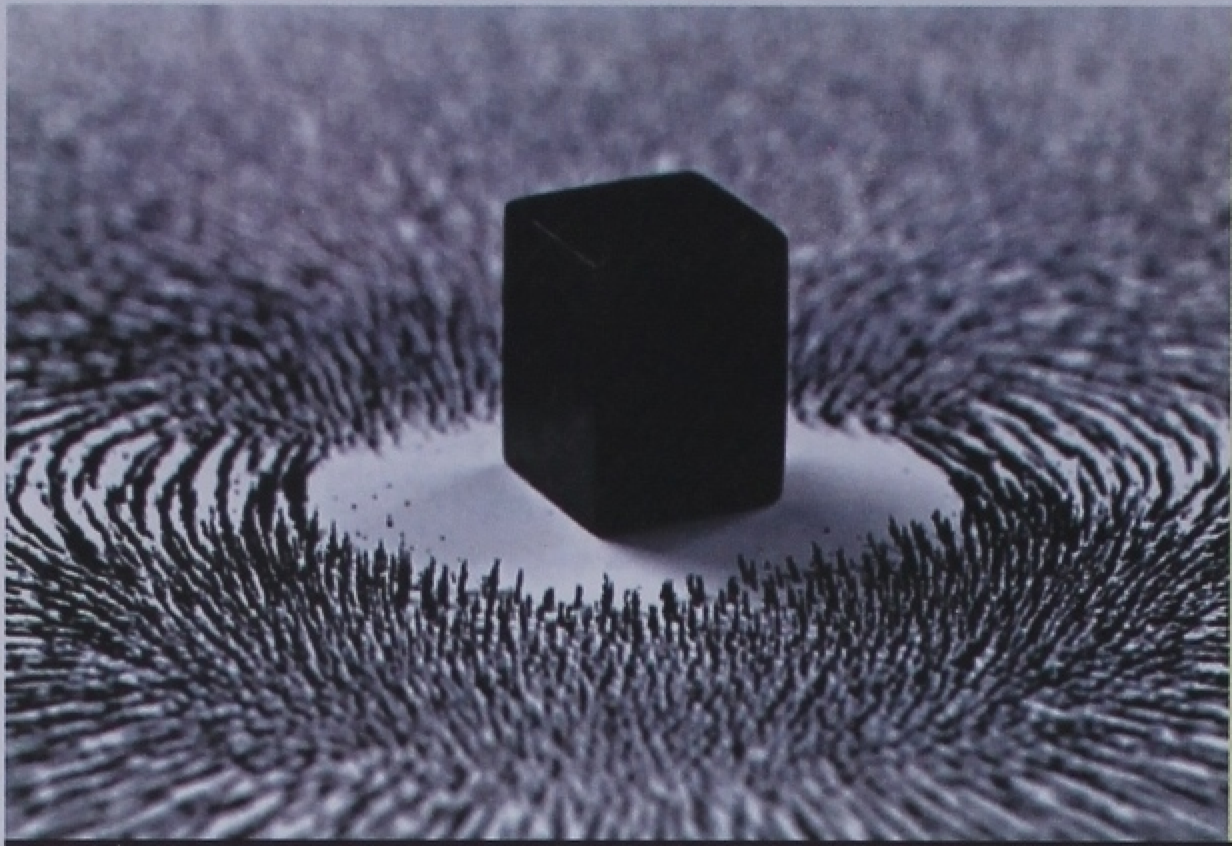


12 Magnetism

You have read in your earlier classes that magnet was first discovered in a small town Magnesia in Asia Minor, around 800 B.C. It was an ore of iron which showed the property of attracting iron objects. This ore was called **Magnetite**. It was found that freely suspended strips of this material always rest in north-south direction. For this characteristic property, it was called the **lodestone.** Through chemical investigations, it was found to be composed of oxides of iron (Fe_3O_4). Now they are called **magnets**. They show the property of attracting iron. This property of attracting iron is known as **magnetism** and the force that a magnet exerts on iron or on another magnet is called **magnetic force**.

Magnetic and non-magnetic substances

Those substances which are attracted by a magnet are called **magnetic substances**. *For example*, iron, cobalt and nickel are called magnetic substances.

Those substances which are not attracted by a magnet are called non-magnetic substances. *For example*, aluminium, copper, wood, plastic, *etc*., are called non-magnetic substances.

PROPERTIES OF A MAGNET

1. Attractive property :

Magnets have attracting property and they attract magnetic substances towards them. This attractive property is zero at the middle and maximum at the ends of a bar magnet.

Experiment : Spread some iron filings uniformly on a table top and then place a magnet (bar magnet) over them.

Now lift the magnet gently and slowly. You will observe that maximum number of iron filings are clinging near the two ends of the magnet and they keep on decreasing towards the centre of the magnet.

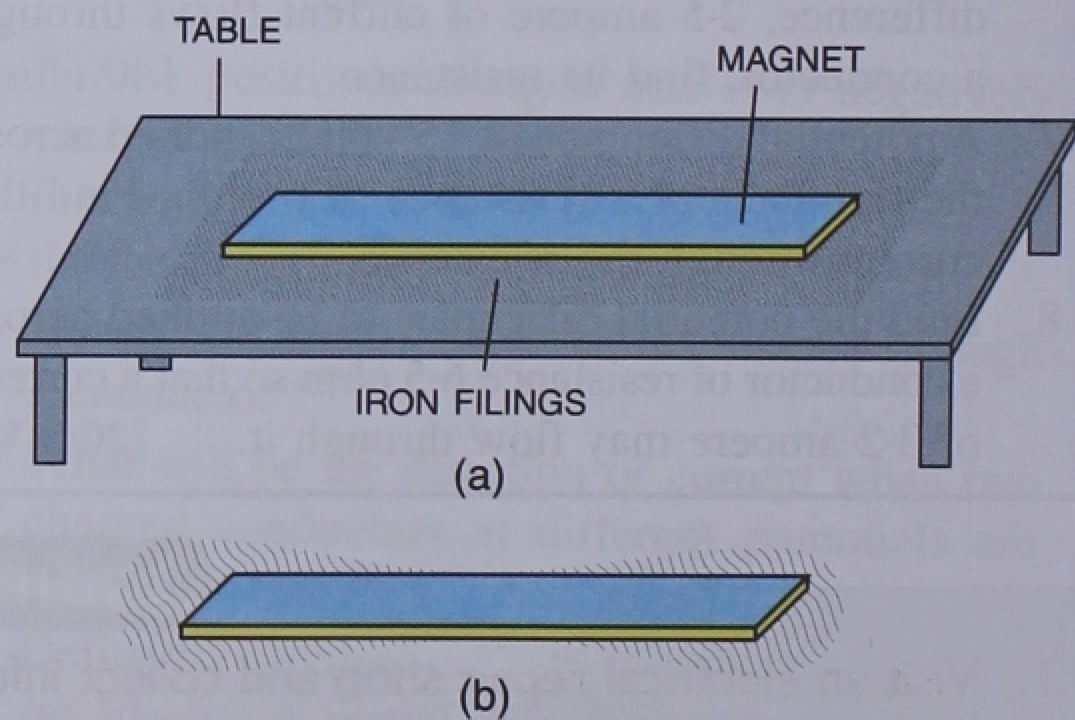


Fig. 12.1 Attraction shown by a bar magnet

Thus, a bar magnet has maximum attractive property at its two ends and zero attractive property at its centre. The two ends of the magnet, at which it has maximum attractive property, are called **poles of the magnet**. A magnet has two poles, the north pole and the south pole. *It must be noted here that the poles are not exactly at the ends of the magnet but they are slightly inside.*

In case of a U-shaped or a horse-shoe magnet, the two open ends serve as the poles. When a U-shaped magnet is dipped in iron filings, the maximum number of iron filings cling at the two ends of it, as shown in Fig. 12.2.

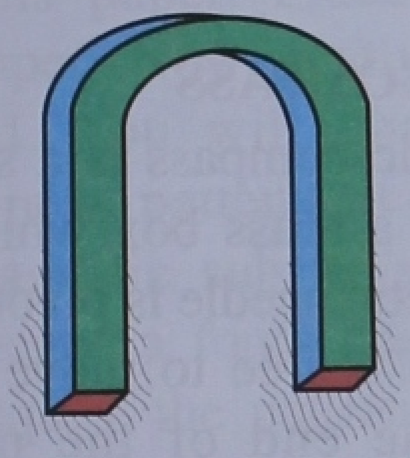


Fig. 12.2 Attraction shown by a U-shaped magnet

2. Directive property :

Suspend a bar magnet freely with the help of a silk thread. Note the direction in which it comes to rest. Now turn the magnet to some other direction and leave it free. Again, note the direction in which it finally comes to rest.

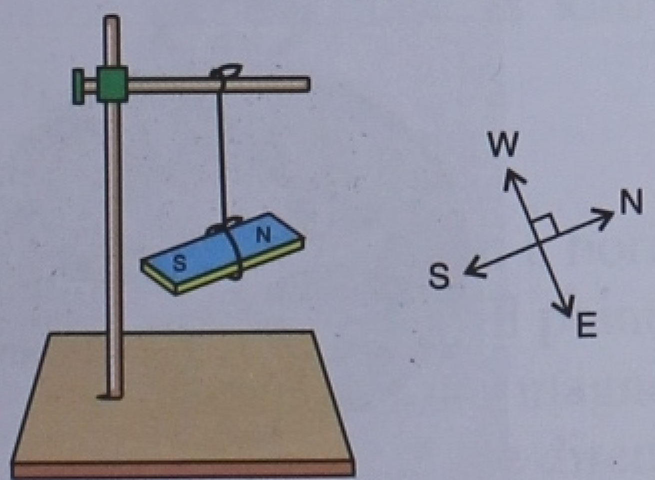


Fig. 12.3 A magnet always takes north-south direction

You will observe that the bar magnet always comes to rest along the north-south direction of the earth (see Fig. 12.3). The end of the bar magnet which point towards the north pole of the earth is called the **north pole** of the magnet, while the end that points to the south pole of the earth is called the **south pole** of the magnet.

The property of a magnet to always point in the north-south direction of the earth is called the **directive property**.

On a magnet, north and south poles are represented by letters N and S respectively.

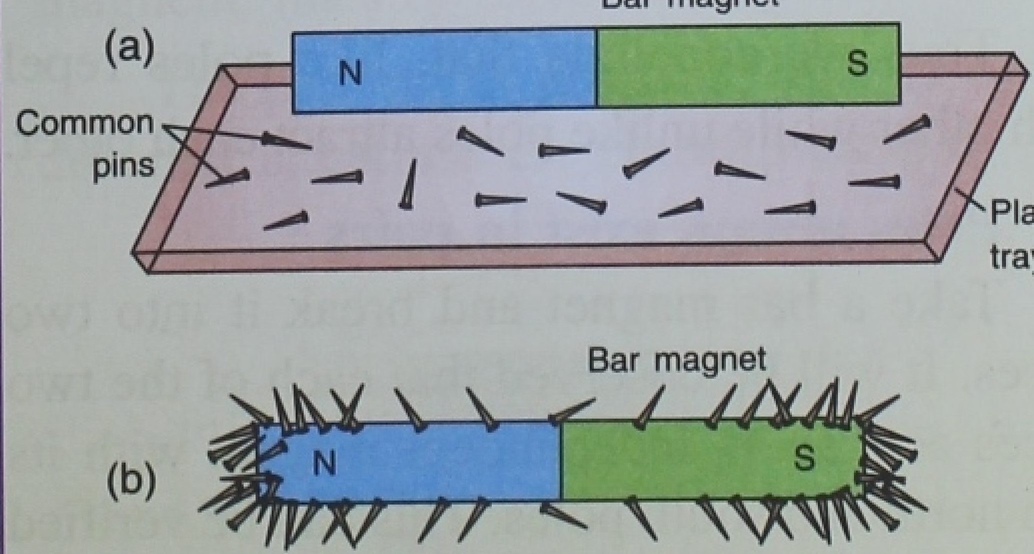
ACTIVITY 1

To show that most of the magnetic strength of magnet acts near its end.

Materials required – A plastic tray, few common pins and a powerful bar magnet.

Procedure – Scatter common pins uniformly in a plastic tray. Place the bar magnet in the tray as shown in the figure. Now lift the magnet.

You will notice that most of the common pins stick to the ends of the magnet. No common pin stick in the middle of the magnet. Hence, it proves that most of the strength of a magnet acts at its ends. The ends are known as the "poles of the magnet".



Pins cling at the ends of bar magnet

3. Like poles repel each other while unlike poles attract :

Take two bar magnets. Suspend one magnet freely with the help of a silk thread. Hold the other magnet in your hand. Take the north pole of the magnet you are holding near the north pole of the suspended magnet. You will find that they repel each other. This will be shown by the north pole of the suspended magnet moves away from the north pole held of the magnet in your hand.

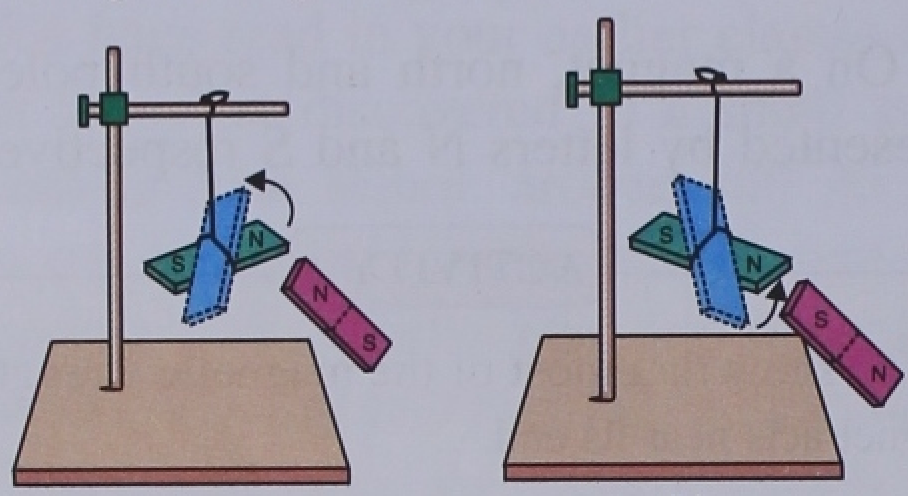


Fig. 12.4 Like poles of two magnets repel and unlike poles attract each other

Now take the south pole of the magnet in your hand near the north pole of the suspended magnet. You will find that the suspended magnet gets attracted to the magnet held by you. The same will happen if you direct the south pole of the magnet you are holding towards the north pole of the suspended magnet (see Fig. 12.4).

Thus we conclude that, like poles repel each other while unlike poles attract each other.

4. Poles always exist in pairs :

Take a bar magnet and break it into two pieces. It will be observed that each of the two pieces acts as an independent magnet with its own north and south poles. This can be verified by using attractive and directive properties of the magnet. Again, break each piece of the magnet into smaller pieces. It will again be observed that each small piece so obtained also behaves like an independent magnet *i.e.* having a north pole and a south pole (see Fig. 12.5). It is not possible to isolate one pole from a magnet, *i.e.,* the north and south poles can not exist separately.

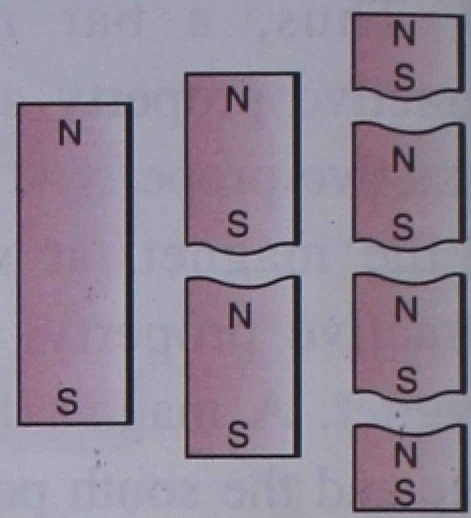


Fig. 12.5 Each part is found to have its own north and south pole

Hence we conclude in a magnet a single pole can never exist or the poles always exist in pairs.

MAGNETIC COMPASS

A magnetic compass is a small magnetic needle kept in a brass box which has a glass top. The magnetic needle is pivoted at its centre *i.e.*, the needle is free to move (rotate) about its centre. The end of the needle, which indicates its north pole, is painted red. When the magnetic compass is placed on the table, the needle rests in the north-south direction with the red end pointing towards north direction. Thus, a magnetic compass is used to locate the direction at a place. It is used by travellers, sailors and navigators to find direction when they sail through an unknown location.

Fig. 12.6 Magnetic compass

ACTIVITY 2

To make a simple magnetic compass.

Materials required : Cork, magnetised needle, a sticker showing all directions.

Procedure : Pass the magnetised needle through the cork. Float it in a trough filled with water, such that the needle is above water. Mark the positions (N and S) when it comes to rest. Stick the sticker with N and S on it exactly at the place N and S marked on the cork.

MAGNETIC FIELD

To understand a magnetic field, let us take the following example.

Place a white sheet of paper on a drawing board. Spread some iron filings evenly on this paper. Place a bar magnet below the paper. Now gently tap the paper on the board. You will observe that iron filings acquire a pattern as shown in Fig. 12.7. The magnetic substance, *i.e.*, the iron filings experience a force due to the magnet and hence acquire the pattern.

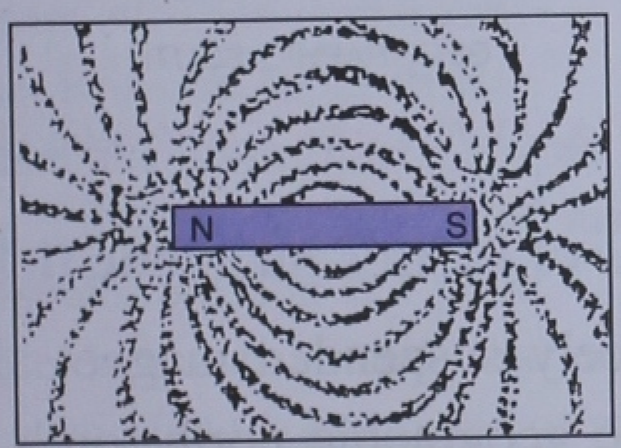
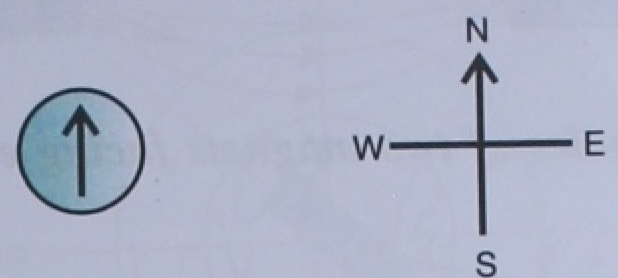


Fig. 12.7 Magnetic field

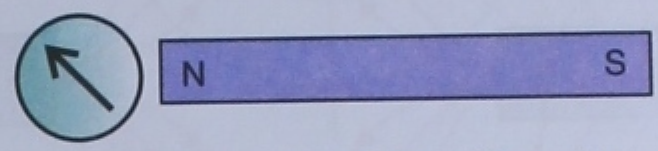
The space around the magnet where its influence can be experienced is known as **magnetic field**.

MAGNETIC LINES OF FORCE

Place a magnetic compass on a horizontal table top. On coming to rest, it will point in the north-south direction. Bring a bar magnet near the magnetic compass and note the direction in which it comes to rest. It will be seen that the magnetic compass needle comes to rest in the direction other than north-south (Fig. 12.8).



(a) Needle in North-South direction



(b) Needle in other direction

Fig. 12.8

Now place the magnetic compass at different points around the bar magnet. As it is moved from one point to the other, the direction of the magnetic compass needle keeps on changing (Fig. 12.9).

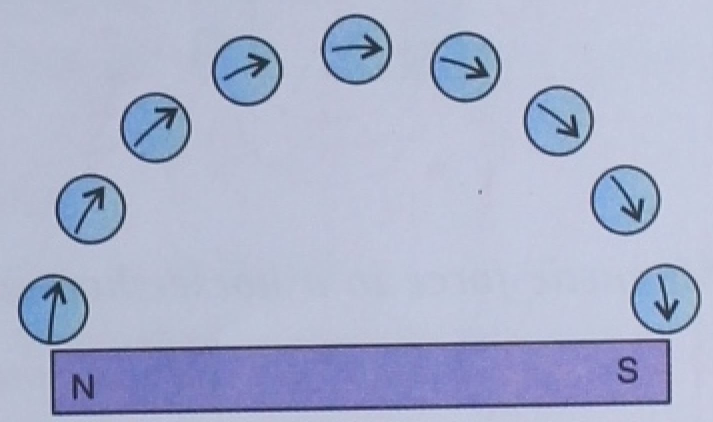
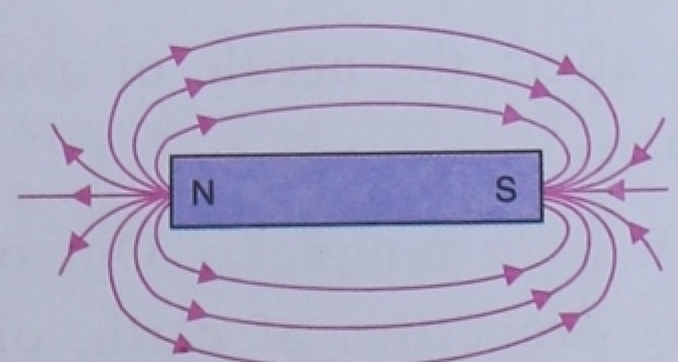


Fig. 12.9 Magnetic lines of force of a bar magnet

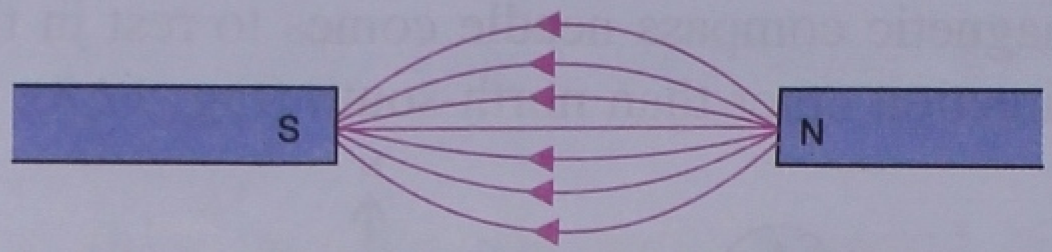
From the above experiment, we conclude that the space around a bar magnet influences the magnetic compass needle.

If a magnetic compass is placed at a point in the magnetic field of a strong magnet, its needle will always rest in the direction of the magnetic lines of force of the field.

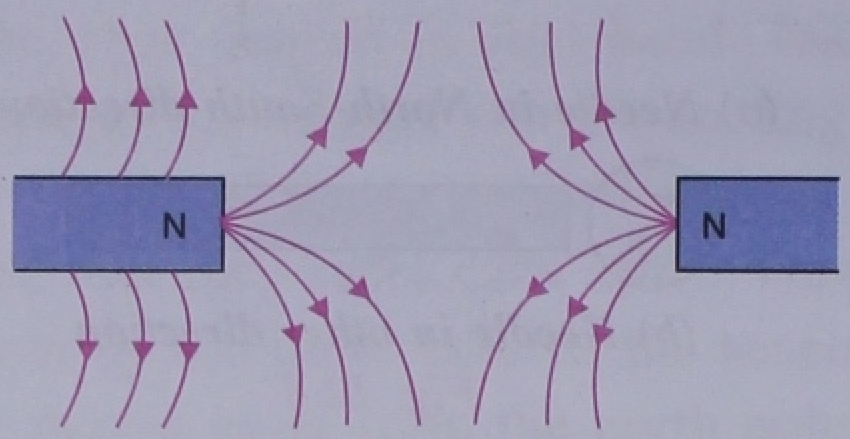
The patterns of magnetic lines of force in different situations are shown below :



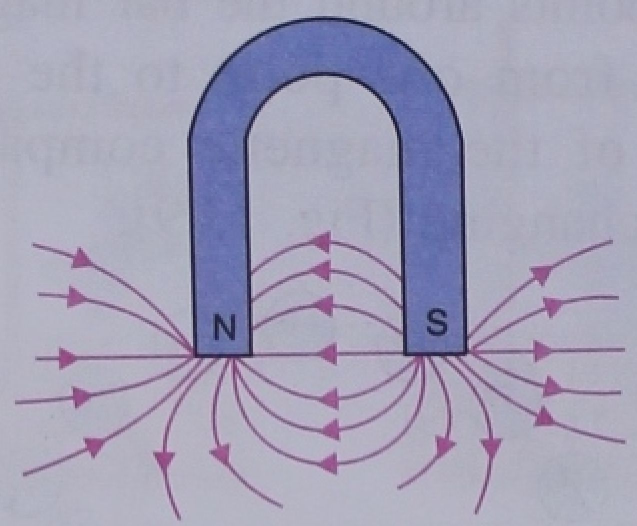
(a) Magnetic lines in a bar magnet



(b) Unlike poles of two magnets facing each other



(c) Like poles of two magnets facing each other



(d) Magnetic force in a horse-shoe magnet

Fig. 12.10 Magnetic lines of force in various magnets

PROPERTIES OF MAGNETIC LINES OF FORCES

(1) Each line is a continuous curve.

(2) Magnetic lines of forces originate from the north pole and terminate at the south pole.

(3) They never intersect each other.

(4) They are crowded near the poles where the magnetic field is strong.

(5) They affect the needle of a magnetic compass.

Earth as a magnet : Out of many interesting properties of earth, one such property is that earth acts like a magnet. The earth may be assumed to have a big magnet buried deep inside the earth with its axis at about 19° to the geographic axis. The north pole of this magnet is closer to the geographic south pole and the south pole is closer to the geographic north pole. The earth's magnet has its own magnetic field called **earth's magnetic field** (Fig. 12.11).

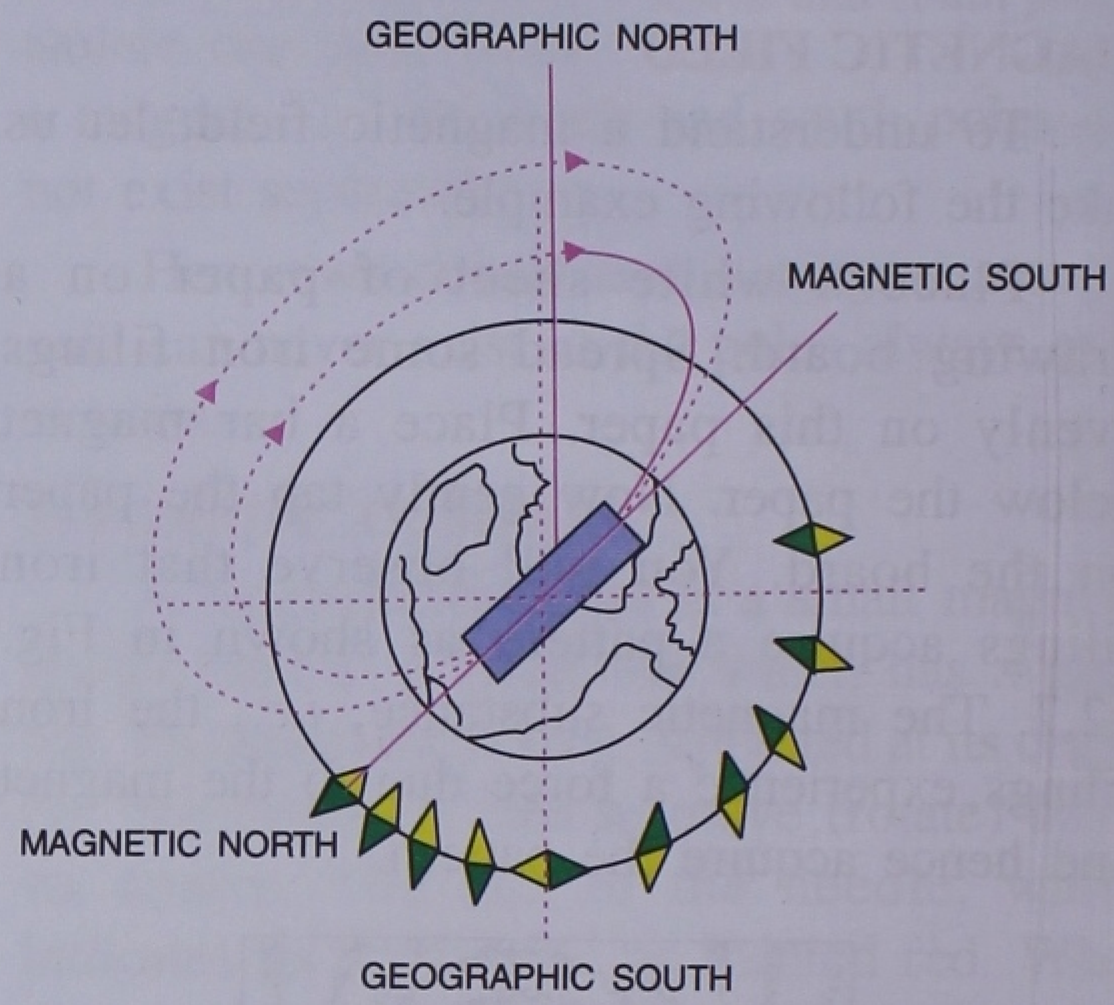


Fig. 12.11 Earth's magnetic field

Evidences of earth's magnetic field :

(1) A freely suspended magnet always rests in the geographic north-south direction. Since the south pole of earth's magnet is closer to the geographic north, the north pole of the freely suspended magnet will rest in the geographic north direction. In the same way, as the north pole of earth's magnet is closer to geographic south, the south pole of the freely suspended magnet will point towards the geographic south direction.

(2) Keep a soft iron rod deep inside the earth along the geographic north-south direction. After a few days, the iron rod becomes a magnet. This reveals that there must be a magnet inside the earth which has magnetised the buried iron rod.

We assume that earth is a huge magnet with its magnetic south pole near the geographic north pole and vice-versa. Figure 12.12 shows that the magnetic poles do not coincide with the geographic poles.

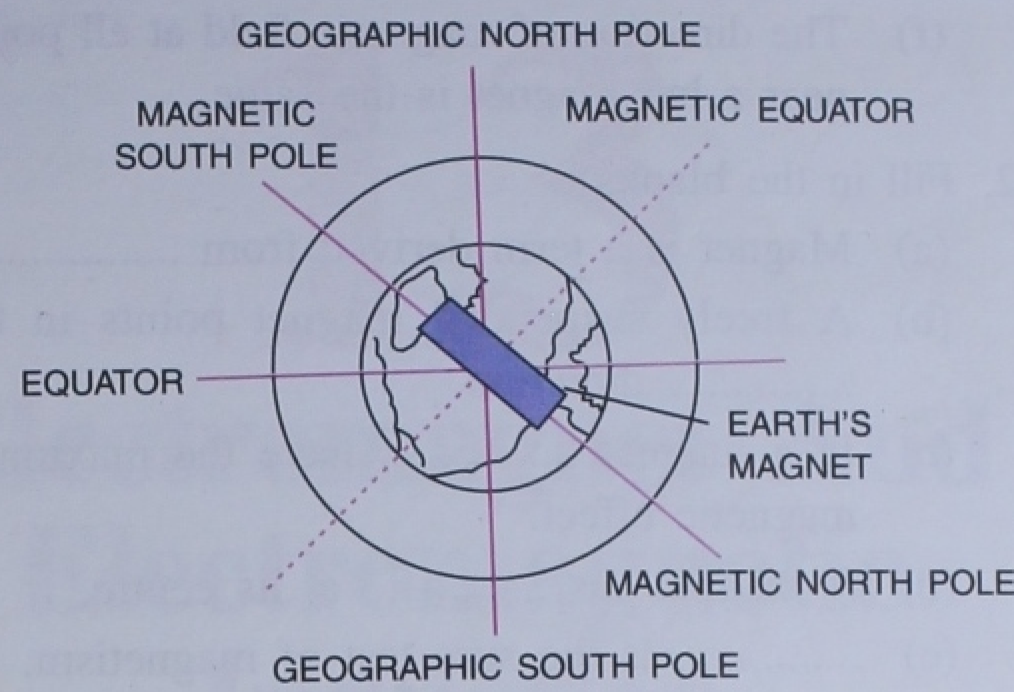


Fig. 12.12 Earth's magnetic field

RECAPITULATION

- A magnet attracts iron pieces and a freely suspended magnet settles along north-south direction.
- The substances which are attracted by a magnet are called magnetic substances.
- The end of a freely suspended bar magnet which settles towards the earth's north pole (geographic) is called the north pole of a magnet.
- Like poles repel each other while unlike poles attract each other.
- Poles always exist in pairs with opposite polarities. Poles cannot be isolated.
- The space surrounding a magnet up to which the magnetic force due to the magnet acts is called its magnetic field.
- The magnetic field is maximum at the poles of a magnet.
- Magnet is neutral at its centre.
- The directive property of a magnet is used in making compass needles.
- A magnetic compass is a small magnetic needle free to rotate about its centre and is used to find the north-south direction at a place.
- At different points around a bar magnet, the magnetic needle rests in different directions.
- A magnetic field is composed of magnetic lines of forces.
- The earth also behaves like a magnet.
- The magnetic lines of force are continuous curves starting from the north pole of the magnet and terminating at its south pole.

TEST YOURSELF

A. Short Answer Questions :

1. Write *true* or *false* for each statement. Rewrite the false statement correctly.
   (a) A magnet can attract only the magnetic substances.
   (b) Magnetic poles exist in pairs.
   (c) Earth behaves like a magnet.
   (d) Poles can be separated from a magnet.
   (e) Two magnetic lines of forces in a magnetic field can intersect each other.

(f) The direction of magnetic field at all points near a bar magnet is the same.

2. Fill in the blanks :
   (a) Magnet is a term derived from ....
   (b) A freely suspended magnet points in the .... direction.
   (c) In a magnet, ... have the maximum magnetic effect.
   (d) A magnet has .... at its centre.
   (e) .... is the sure test of magnetism.
   (f) .... cannot be isolated from a magnet.
   (g) Magnetic lines of force due to a bar magnet are directed from .... pole to the .... pole outside a magnet.
   (h) The south pole of the earth's magnet is near the geographic ....

3. Match the following :

(a) Earth behaves like a	(i) never intersect
(b) Freely suspended magnet	(ii) rests in N-S direction
(c) Magnetic lines of force	(iii) magnet

4. Tick the most appropriate answer :
   (a) If we suspend a magnet freely, it will settle in
      (i) east-west direction
      (ii) north-south direction
      (iii) north-east direction
      (iv) east-south direction
   (b) The attraction of a magnetic substance by poles of a magnet is
      (i) minimum (ii) zero
      (iii) maximum (iv) none of these
   (c) For a given magnet
      (i) north pole is stronger than south pole
      (ii) both poles are of equal strength
      (iii) south pole is stronger than north pole
      (iv) none of these.
   (d) Earth's magnet has its south pole situated near the
      (i) geographic north
      (ii) geographic south
      (iii) geographic west
      (iv) geographic east.
   (e) An example of natural magnet is
      (i) iron (ii) steel
      (iii) lodestone (iv) none of these
   (f) The magnetic lines of force due to a bar magnet are
      (i) continuous and intersecting
      (ii) discontinuous and non-intersecting
      (iii) continuous and non-intersecting
      (iv) continuous and crowded at the middle of the magnet.

5. Answer the following questions :
   (a) How will you show that magnet has directive property ?
   (b) What are the important uses of a magnet ?
   (c) Give the properties of magnetic lines of force.
   (d) How will you test whether a given rod is a magnet or not ?
   (e) One of the two rods, identical in shape, is a magnet and the other is of soft iron. How will you distinguish them ?
   (f) How can a bar magnet be used to know the north-south direction of a place ?

6. Describe :
   (a) a magnetic compass
   (b) magnetic field
   (c) magnetic lines of force
   (d) earth's magnetism

7. State the use of a magnetic compass.

8. Will a magnetic compass needle, placed near a bar magnet, rest in north-south direction ? Explain.

9. State two properties of magnetic lines of force.

10. How will you use a bar magnet and some iron filings to obtain the magnetic lines of force ?