SUBJECT : SCIENCE (PHY)

CHAPTER-13:

MAGNETIC EFFECT OF ELECTRIC CURRENT

TOPIC-4:

MAGNETIC FIELD DUE TO A CURRENT IN A SOLENOID:

OBJECTIVES:

Upon completion of the topic, you will be able to

1. DEFINE SOLENOID
2. EXPLAIN WHAT HAPPEN WHEN CURRENT IS PASSED THROUGH A SOLENOID
3. DRAW THE MAGNETIC LINES OF FORCE AROUND SOLENOID CARRYING CURRENT.
4. DEFINE ELECTROMAGNET
5. WRITE USES OF SOLENOID
6. WRITE USES OF ELECTROMAGNET

SOLENOID:

4.06. Magnetic Field due to a Current in a Solenoid

A solenoid is a coil of many turns of an insulated copper wire closely wound in the shape of a tight spring.

Or

A solenoid is a long, helically wound coil of insulated copper *wire.*

A solenoid is shown in figure 20.

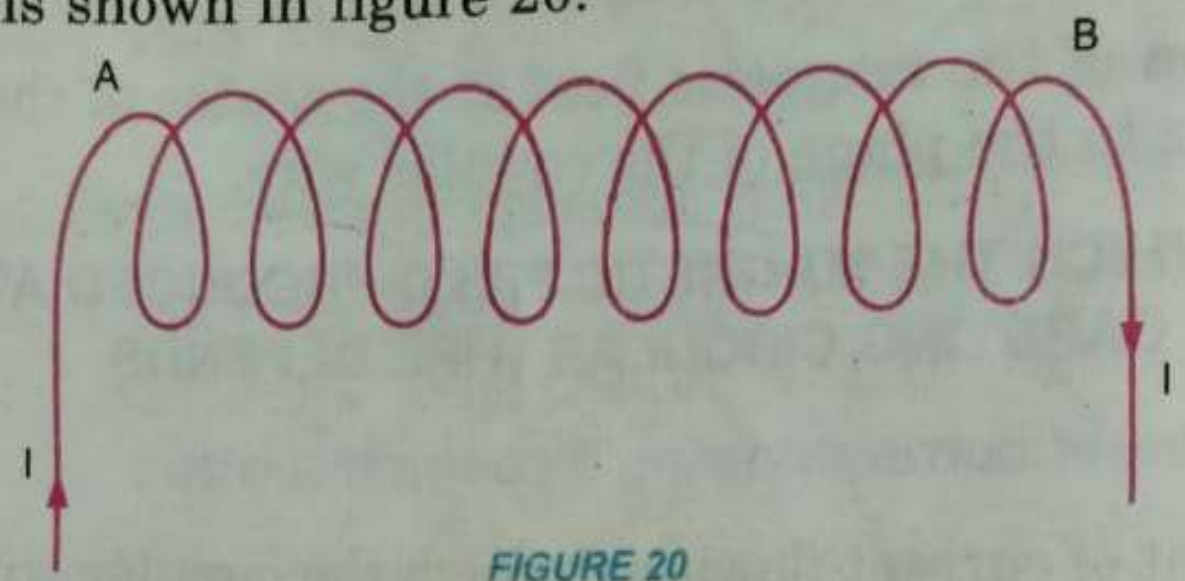


FIGURE 20

MAGNETIC FIELD DUE TO A CURRENT CARRYING SOLENOID:

When an electric current flows through a solenoid, a magnetic field is set up which is similar to the magnetic field of a bar magnet. The magnetic field due to a solenoid carrying current is shown in figure 21.

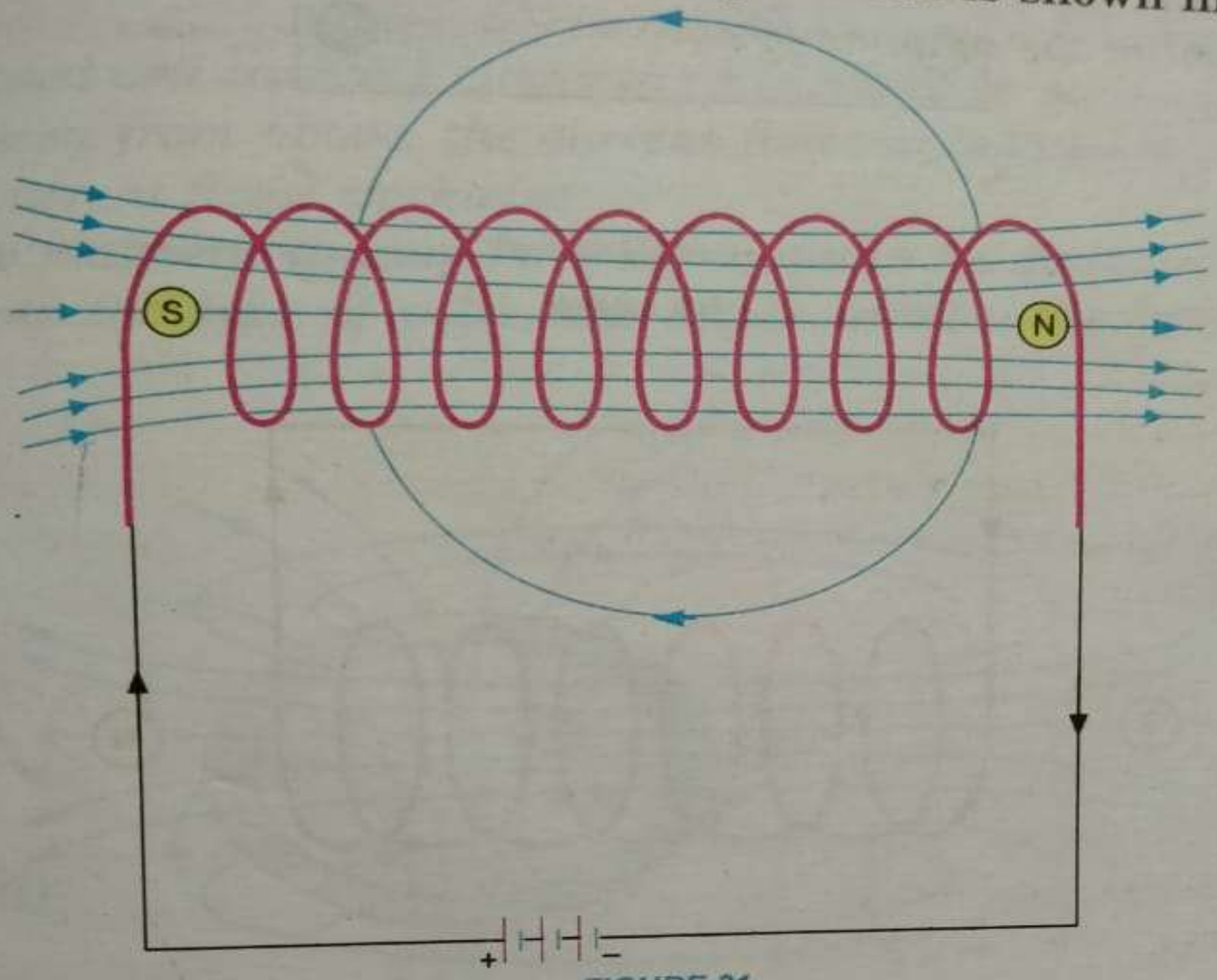


FIGURE 21

One end of the solenoid acts as *South* pole and the other end acts as *North* pole. *If the current flows in a clockwise direction when the coil is seen end–on, then that end of the solenoid acts as a South pole.* On the other hand, *if the current flows in anticlockwise direction when the coil is seen end–on, then that end of the solenoid acts as a North pole* (Figure 22).

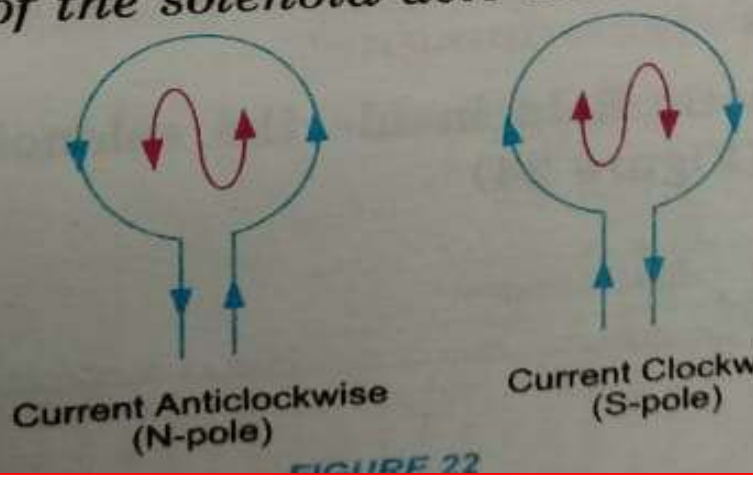


FIGURE 22

Next Slide

Thus, face or end B of the solenoid behaves as South pole and face or end A of the solenoid behaves as North pole. In other words, a current carrying solenoid behaves as a bar magnet.

It may be noted that : (Features of solenoid):

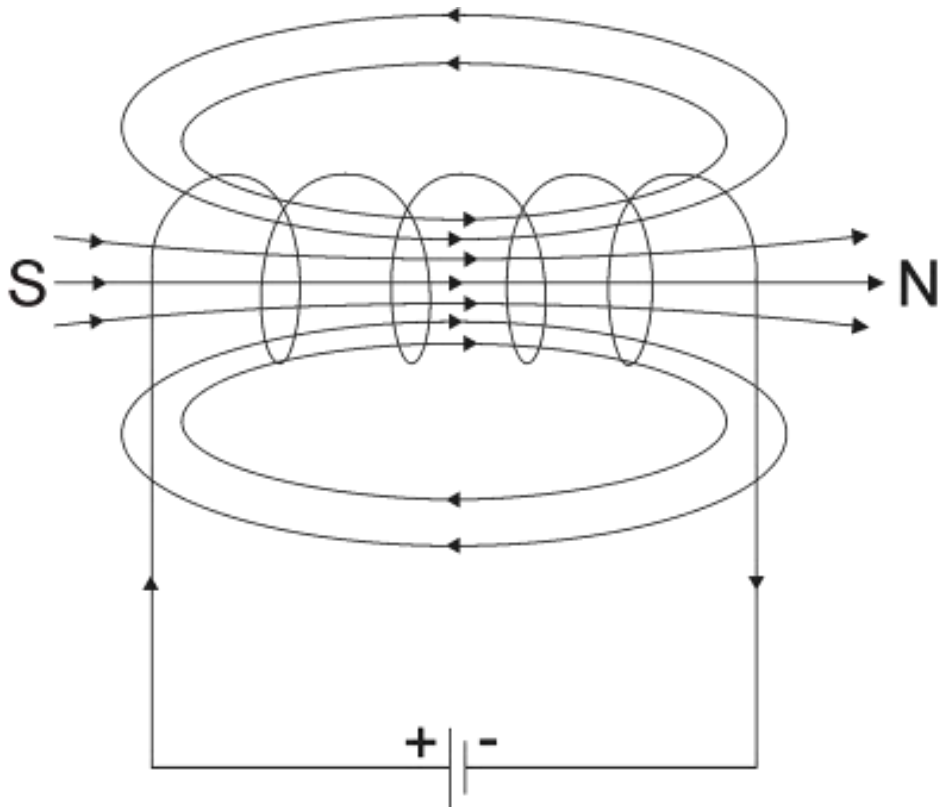
(i) Magnetic field inside a long solenoid is uniform and strong.

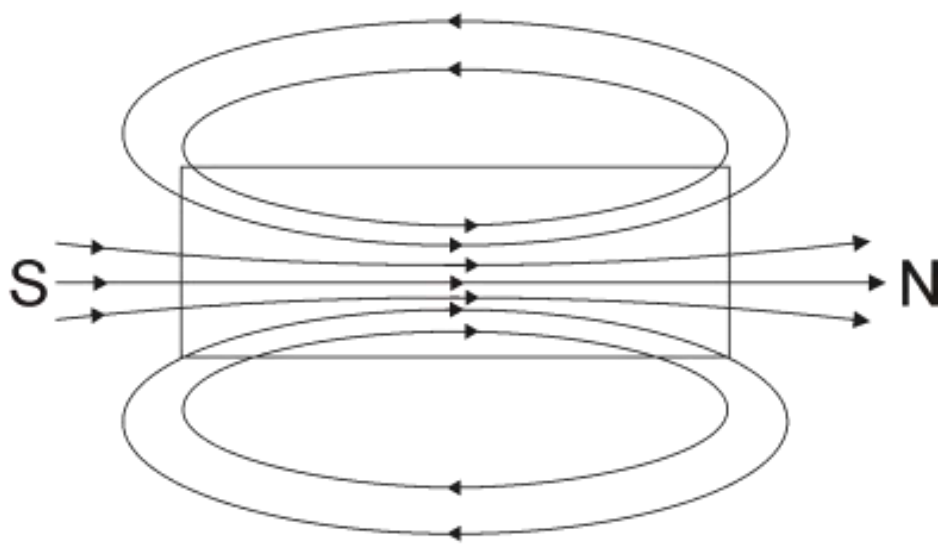
(ii) Magnetic field inside a long solenoid decreases as we move towards the ends of the solenoid because magnetic field lines near the ends of the solenoid start spreading out.

(iii) Magnetic field outside the solenoid is non–uniform.

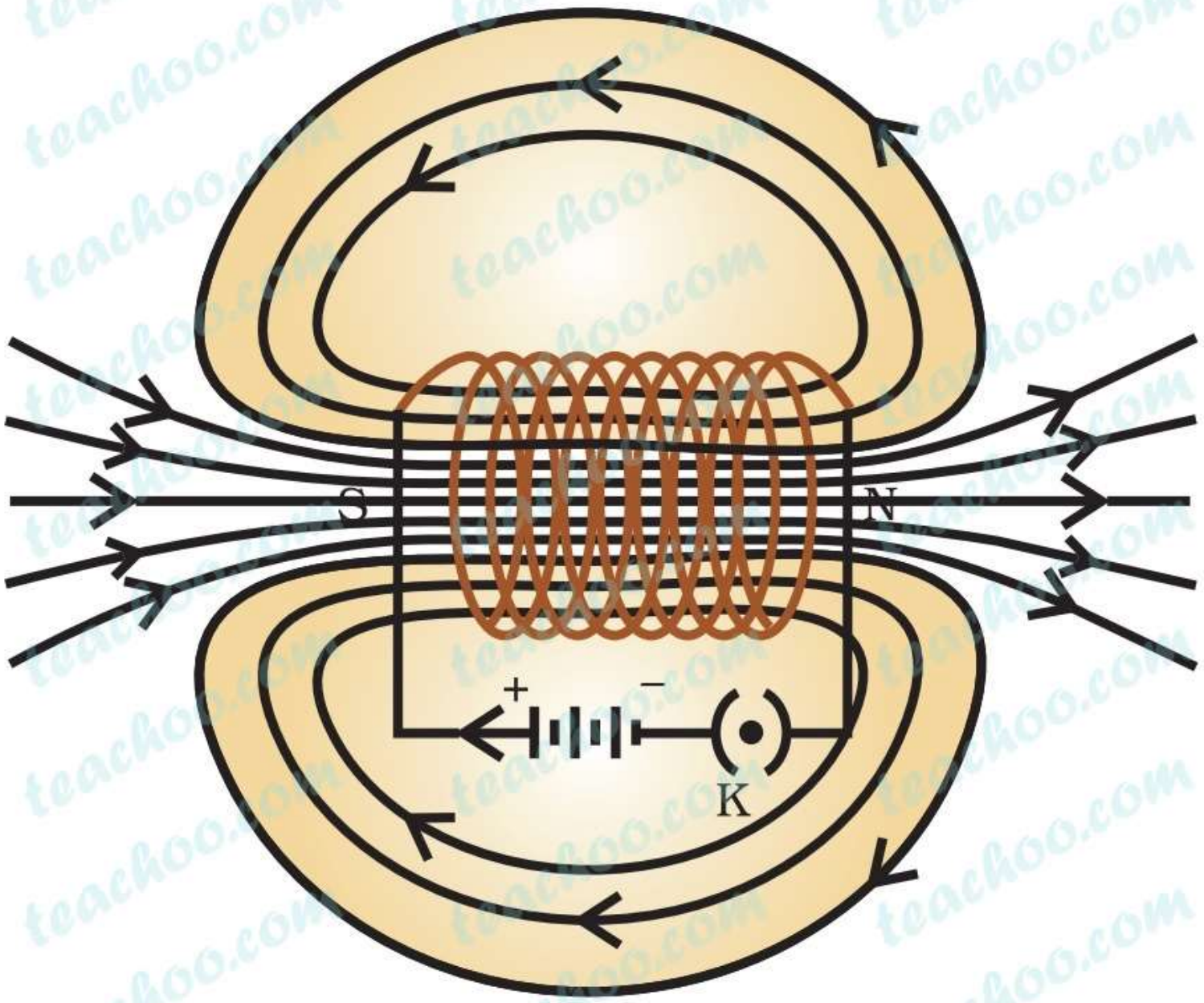
(iv) Magnetic lines of force inside the solenoid are from South pole to North pole and outside the solenoid, these lines of force are from North pole to South pole.

(v) The magnetic field of the solenoid resembles the magnetic field of the bar magnet





Magnetic Field in a Solenoid



FACTORS ON WHICH STRENGTH OF MAGNETIC FIELD STRENGTH DUE TO CURRENT CARRYING SOLENOID DEPENDS:

1. Electric current (I):

   Field strength(B) is directly proportional to electric current (I) passing through it : $B \propto I$

2. Number of turns per unit length (n):

   Field strength(B) is directly proportional to number of turns per unit length(n) : $B \propto n$

ELECTROMAGNET:

4.06.1. ELECTROMAGNETS

When a soft iron bar is placed inside a solenoid carrying current, it becomes a magnet as long as current flows through the solenoid. Such a magnet is known as **electromagnet**.

In fact, the magnetic field inside the solenoid magnetises the soft iron bar placed in it. (Figure 24)

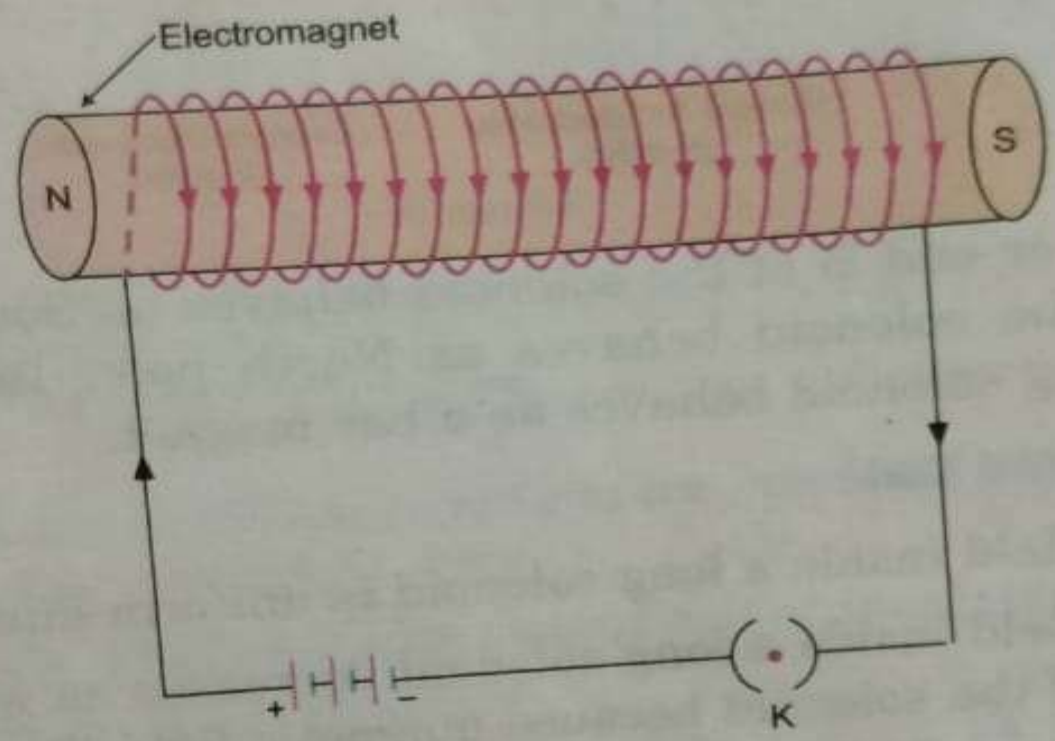


FIGURE 24

Uses of electromagnets

(i) They are used to lift heavy iron pieces. They are fitted on cranes lifting heavy masses of scrap iron.

(ii) They are used in many devices like electric bell, electric horn, telephone receiver, electric relay, microphones, radio set, television, loudspeakers etc.

Applications of Solenoid

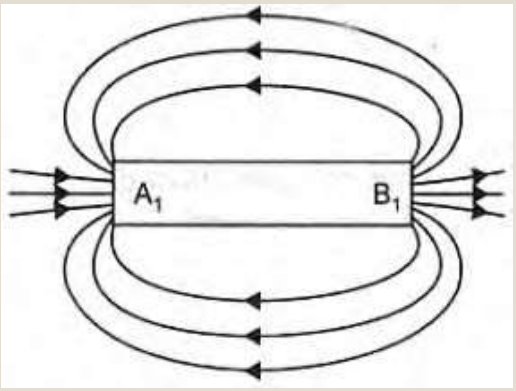
- A solenoid is an essential coil of wire that is used in electromagnets, inductors, antennas, valves, etc. ...
- Solenoids can be used to slow the flow of electricity in a circuit

Q1:State the direction of the magnetic field inside the bar magnet.
[CBSE 2016]

Ans1 :

In a magnet, magnetic field lines goes from S pole to N pole.

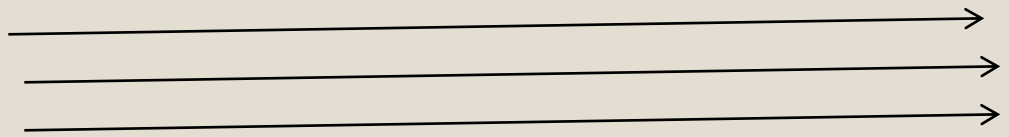
Q2:Identify the poles of the magnet in the given figure. [CBSE 2016]



ANS2: A1 is North Pole, B1 is South Pole because magnetic field lines goes from north pole to south pole of the magnet.

Q3: Draw a diagram to represent a uniform magnetic field in a given region.

ANS: Uniform magnetic field is represented by equidistant parallel lines.



Q4:What type of core is used to make an electromagnet? [CBSE 2015]

Ans 4:

Soft iron core is used in making an electromagnet.

Q5: How can it be shown that a magnetic field exists around a wire through which a direct current is passing. [Delhi 2014]

Ans :

When we put a small magnetic compass near a current carrying conductor it gets deflected, which shows that a magnetic field is produced near a current carrying conductor.

Q6:How is the strength of the magnetic field at a point near a wire related to the strength of the electric current flowing in the wire? [CBSE 2009]

Ans :

The magnetic field strength at a point near a wire is directly proportional to the current strength in the conductor.

Q7:How can you show that the magnetic field produced by a given electric current in the wire decreases as the distance from the wire decreases? [CBSE 2006]

Ans :

If we bring a magnetic compass from a distance to near a current carrying conductor its deflection goes on increasing and when magnetic compass is brought away from the current carrying wire its deflection goes on decreasing which shows that magnetic field near current carrying wire is maximum and decreasing on increasing the separation.

Q8: What is the pattern of field fines inside a solenoid? What do they indicate?

ANS:The magnetic field inside a solenoid is uniform in the form of parallel lines.

Q9:How is the magnetic field produced in a solenoid used? [CBSE 2010]

Ans :

Magnetic field produced in a solenoid can be used in making a soft iron piece electromagnet.

Q10: What does the direction of thumb indicate in the right-hand thumb rule? [CBSE 2010]

Ans :

Thumb points the direction of current in the conductor holding a straight conductor in right hand.

Q11:
(a) In a pattern of magnetic field fines due to a bar magnet, how can the regions of relative strength be identified?
(b) Compare the strength of field near the poles and middle of a bar magnet. [CBSE 2014]

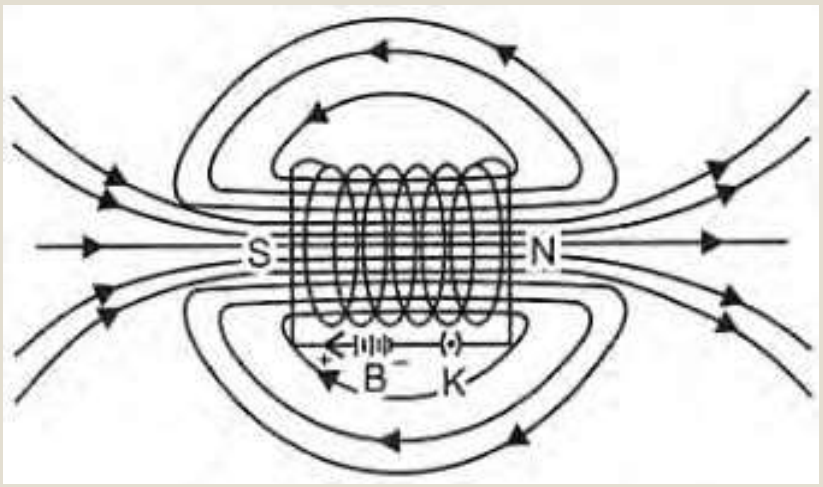
Ans :

More the density of the magnetic field lines i.e. more closer the magnetic field lines more the strength of magnetic field.
Near the poles magnetic field lines are closer than the middle of a bar magnet. So magnetic strength is more near poles than middle part of bar magnet.

Q12:Draw the pattern of field lines due to a solenoid carrying electric current. Mark the north and south poles in the diagram. [CBSE 2004]

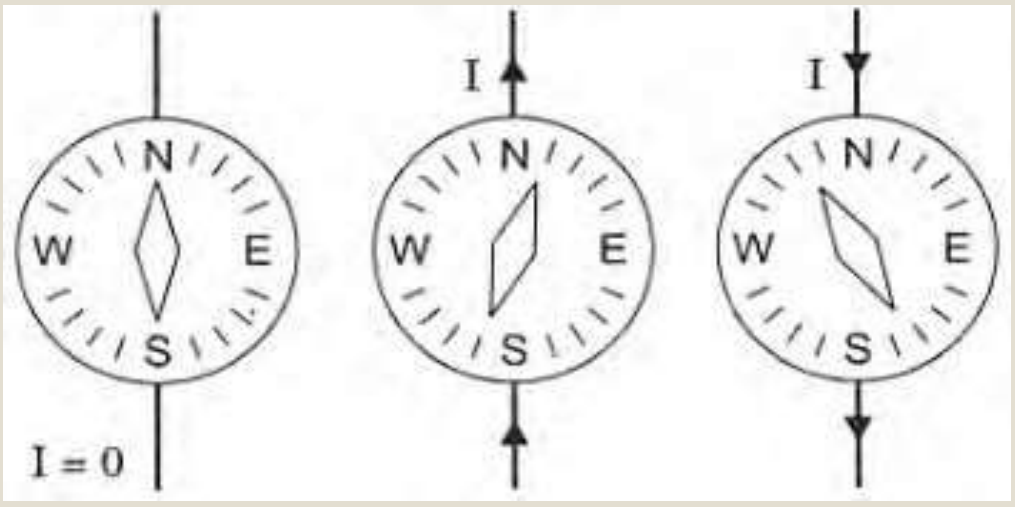
Ans :

The pattern of the magnetic field lines is as shown in figure.



Q13:Draw a diagram to show how a magnetic needle deflects when it is placed above or below a straight conductor carrying current depending on the direction of the current in the conductor. [CBSE 2010]

Ans :

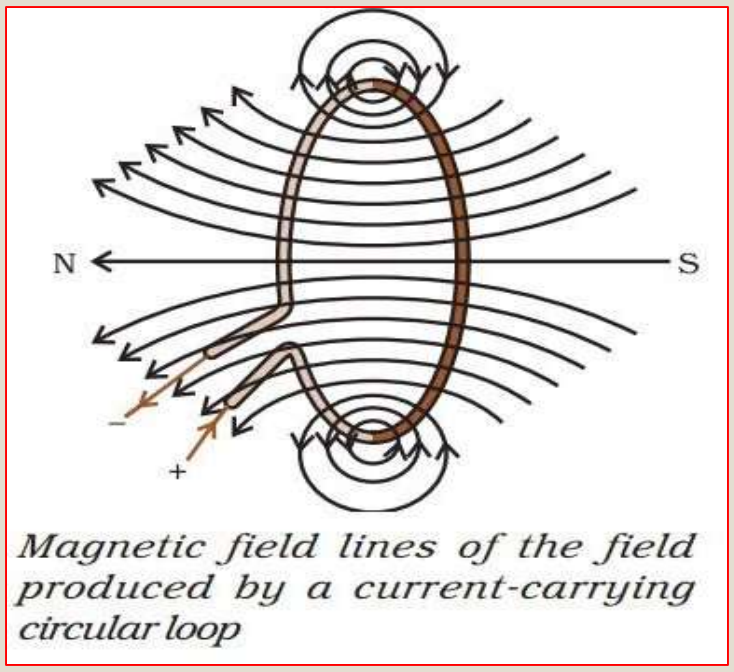


Question 14:

Consider a circular loop of wire lying in the plane of the table. Let the current pass through the loop clockwise. Apply the right-hand rule to find out the direction of the magnetic field inside and outside the loop.

Answer 14:

The magnetic field lines have been shown in Figure given below. As per right-hand rule, we find that inside the loop, the magnetic field lines are directed perpendicular to the plane of paper in the inward direction. Outside the loop magnetic field lines are directed out of the plane of paper.



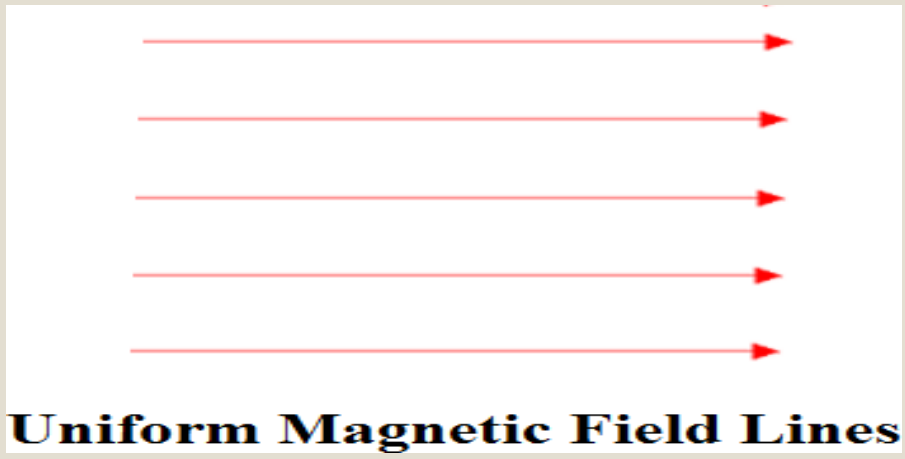
Magnetic field lines of the field produced by a current-carrying circular loop

Question 15:

The magnetic field in a given region is uniform. Draw a diagram to represent it.

Answer 15:

The uniform magnetic field is represented by parallel, equidistant lines of equal length as shown in Figure.



Uniform Magnetic Field Lines

Question 16:

Choose the correct option.

The magnetic field inside a long straight solenoid-carrying current

(a) is zero.

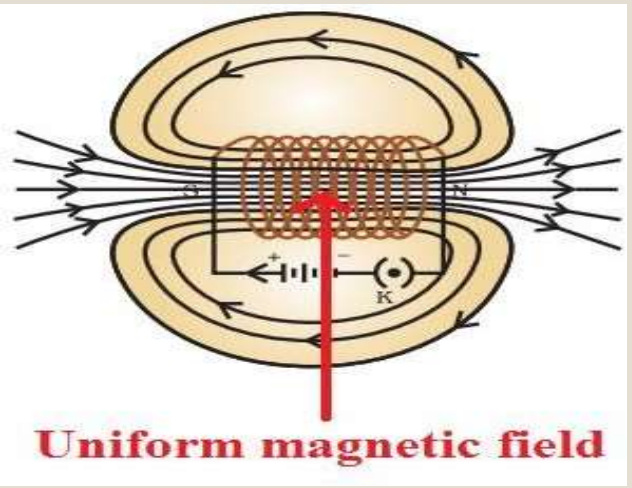
(b) decreases as we move towards its end.

(c) increases as we move towards its end.

(d) is the same at all points.

Answer 16:

(d) is the same at all points.



Question 17:

List three sources of magnetic fields(or method of producing magnetic field)

Answer 17:

Three methods of producing magnetic field are as follows:

(a) Magnetic field can be produced by placing a permanent bar magnet or a horse-shoe magnet at the place, where magnetic field is required.

(b) Magnetic field is produced around a current-carrying straight conductor or a current carrying circular coil.

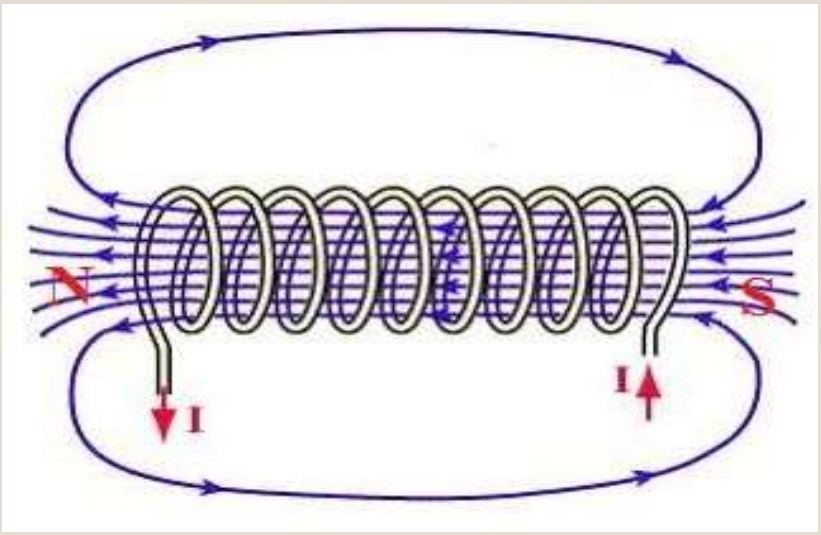
(c) A very good method to produce magnetic field is due to flow of current in a solenoid.

Question 18:

How does a solenoid behave like a magnet? Can you determine the north and south poles of a current–carrying solenoid with the help of a bar magnet? Explain.

Answer18:

When current is passed through a solenoid coil, magnetic field produced due to each turn of solenoid coil is in the same direction. As a resu1t, the resultant magnetic field become very strong and uniform. The field lines inside the solenoid are in the form of parallel straight lines along the axis of solenoid. Thus, the solenoid behaves like a bar magnet. One end of solenoid behaves as a magnetic North pole while the other end behaves as the South Pole.



We can determine the magnetic poles formed in a solenoid. The end of the current-carrying solenoid, which attracts North Pole but repels South Pole of a bar magnet, is behaving as south magnetic pole. The other end, which attracts South Pole of a bar magnet but repels the North Pole, is behaving as north magnetic pole. It is because like poles repel but unlike poles attract each other.

QUESTION-19: Write the differences between circular loop and a solenoid.

QUESTION-20: How will you determine the end of a current carrying solenoid where North pole is formed? **(HOME- WORK)**