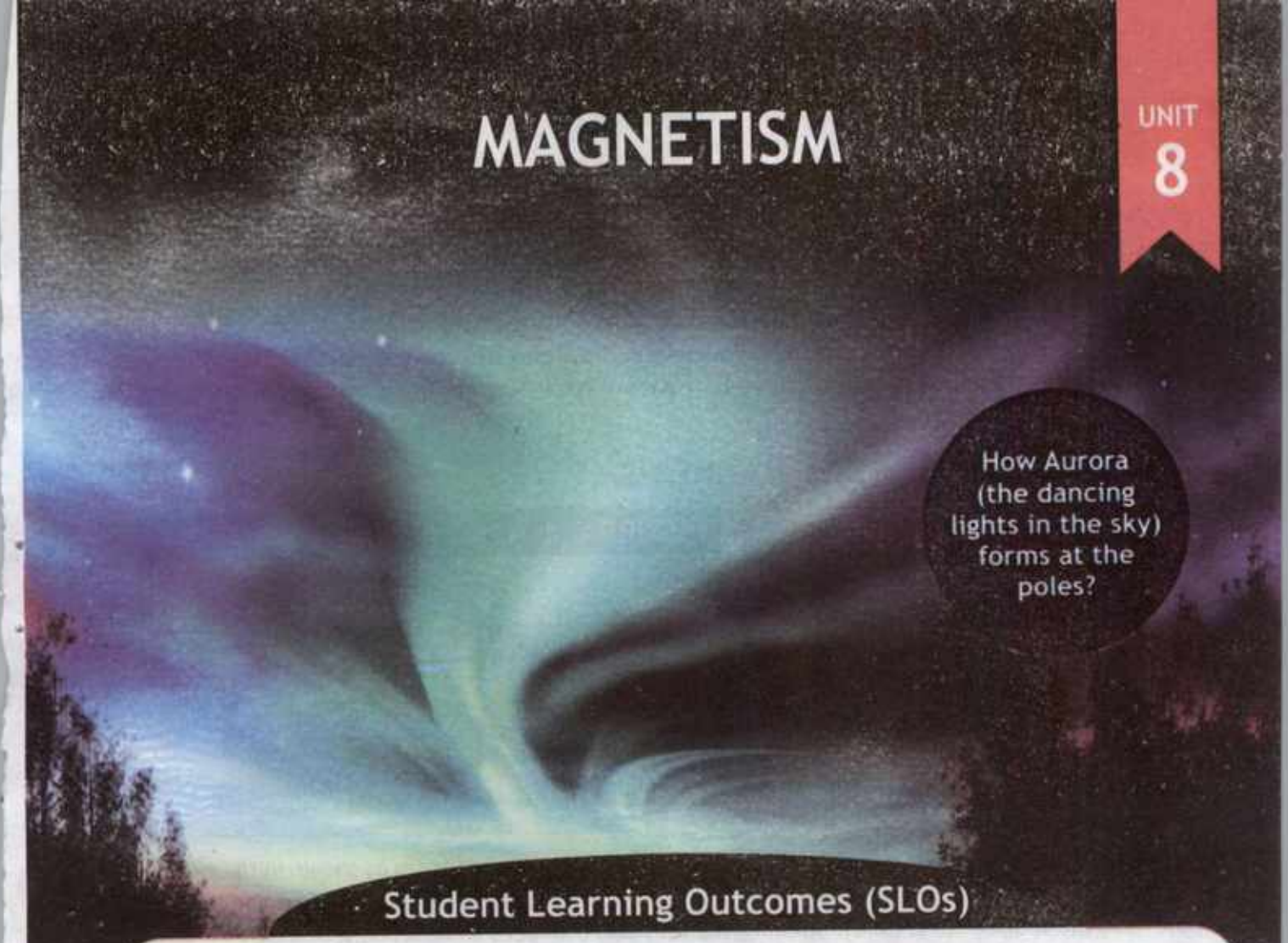
MAGNETISM

UNIT 8



How Aurora (the dancing lights in the sky) forms at the poles?

Student Learning Outcomes (SLOs)

The students will:

- [SLO: P-09-E-01] Describe the forces between magnetic poles and between magnets and magnetic materials.
- [SLO: P-09-E-02] Describe induced magnetism.
- [SLO: P-09-E-03] State the difference between magnetic and non-magnetic materials.
- [SLO: P-09-E-04] Differentiate between temporary and permanent magnets.
- [SLO: P-09-E-05] Describe magnetic fields.
- [SLO: P-09-E-06] Illustrate the plotting of magnetic field lines with a compass or iron filings.
- [SLO: P-09-E-07] Draw the pattern and direction of the magnetic field lines around a bar magnet.
- [SLO: P-09-E-08] State that the direction of the magnetic field at a point is the direction of the force on the N pole of a magnet at that point.
- [SLO: P-09-E-09] state that the relative strength of a magnetic field is represented by the spacing of the magnetic field lines.
- [SLO: P-09-E-10] Describe uses of permanent magnets and electromagnets.
- [SLO: P-09-E-11] Explain qualitatively in terms of the domain theory of magnetism how materials can be magnetized and demagnetized.
- [SLO: P-09-E-12] Differentiate between ferromagnetic, paramagnetic and diamagnetic materials.
- [SLO: P-09-E-13] Describe the nature of the Earth's magnetic field.
- [SLO: P-09-E-14] Analyze applications of magnets in recording technology.
- [SLO: P-09-E-15] State that soft magnetic materials (such as soft iron) can be used to provide shielding from magnetic fields.

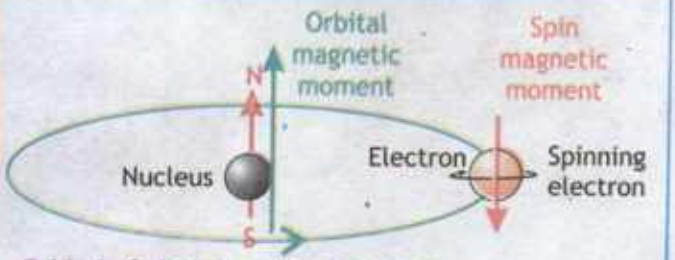
UNIT 8 MAGNETISM

Magnetism finds its history to times back to the 600 BC, when the early loadstone, attracting the iron was found in the region of magnesia, from where it takes the name 'magnet'. Though it dates long ago but man begun to understand magnetism in the twentieth century and started developing technologies on this understanding. Magnetism arises due to motion of charge particles like electrons moving around the nucleus in the atoms and charges moving in the wires in the form of electric current. Now a day we have a lot of technological applications of magnets and magnetism.

8.1 DOMAIN THEORY OF MAGNETISM

As we know everything around us is made up of atoms, having massive central body with positive charge known as nucleus and light particles with negative charge called electrons orbit around the nucleus. In late twentieth century we found that the basis of magnetism is the motion of charge particles. Electrons (charged particles) move around the nucleus in all atoms producing magnetism.

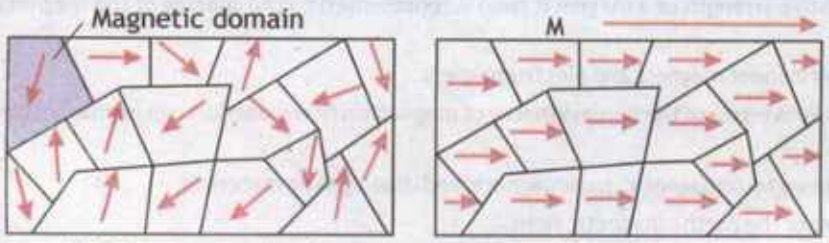
FIGURE 8.1 MAGNETISM IN AN ATOM



So for a single atom each electron produces a small amount of magnetism as shown in figure 8.1. For a single electron loop a tiny magnet is produced which has two poles called the north-pole (N pole) and the south-pole (S pole). Spinning nucleus also produces some amount of magnetic field but that is negligibly small and the spin motion of electron also produces a tiny magnetism, hence we take the magnetic field of atoms only due to orbital motion of electrons. In some atoms electrons are so oriented that they may add up their magnetic field to make the atom with net non-zero magnetic field, which makes the whole material as magnetic material.

In a sizeable piece of a material a group of atoms having parallel magnetic field make a 'domain' (of roughly 10^{12} atoms and a size of few mm). In unmagnetized material the domains are randomly oriented while in a magnetized material (a material can be magnetized by placing it in external magnetic field) the domains are aligned, as shown in figure 8.2.

FIGURE 8.2 DOMAINS



FOR YOUR INFORMATION

"A domain is the group of atoms in a material which have n-poles pointing in the same direction".

8.1.1 Force between magneticpoles:

As we seen above that a magnet, how small it may be, have an S-pole and N-pole. In magnets like poles repel each other while unlike poles attract each other. Similarly the materials which have magnetism are attracted by the opposite poles of a magnet. A magnetic material can also attract opposite poles of other magnetic materials as shown in figure 8.3.

FIGURE 8.3 MAGNET



Force between magnet and magnetic material

8.2 MAGNETIC FIELD

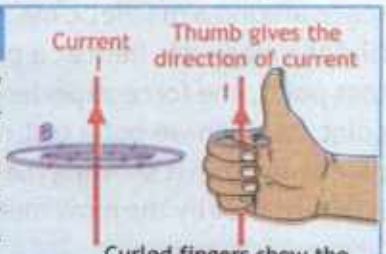
Mono-pole never exist in magnets, magnets are always bipolar i.e. they have two poles N-pole and S-pole. Every magnet has a space around it where it has its influence on other magnets in the form of attraction or repulsion.

"The region or space around a magnet where it exerts a force on other magnetic poles is called magnetic field".

The intensity of magnetic field (B) at any point in the field can be measured in the unit called tesla (T). Graphically the magnetic field is represented by the field lines. The direction of the magnetic field of a material at any point can be found by the direction of force acting on the N-pole placed at that point. Magnetic field lines are curved in general, hence the direction of magnetic field on a point at such a curved line can be found by drawing a tangent at that point.

INFORMATION

Magnetic field (B) of a wire carrying a current (I) can be found by placing iron filling around the wire. We get the magnetic field of current carrying wire as the concentric circles having centers in the wire. The direction of such field can be found by using right hand rule. Hold the current carrying wire in your right hand, the fingers will curve in the direction of magnetic field.

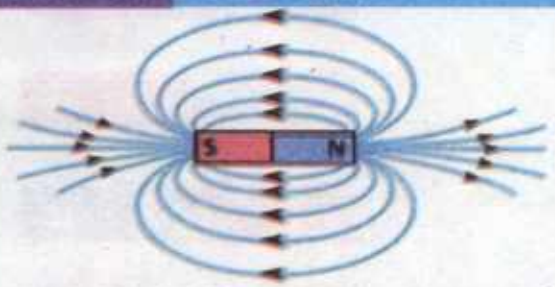


Curled fingers show the direction of magnetic field

8.2.1 Magnetic Field of a Bar Magnet:

A bar magnet is a rectangular part of a material which shows permanent magnetic properties. The magnetic field of a bar magnet can be found by placing the magnet on a plane sheet such that it has compass needles around it. You will notice that all the compass needles point in a particular manner, which shows the magnetic field pattern of the bar magnet, as shown in figure 8.4.

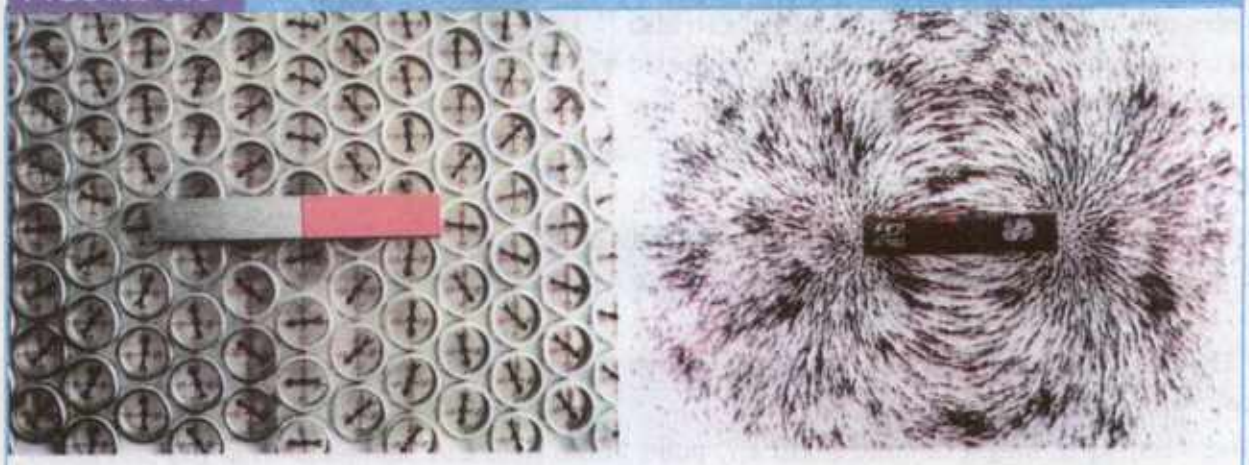
FIGURE 8.4 FIELD LINES



Magnetic field lines of a bar magnet

The field lines originate from N-pole and terminate at S-pole, while within the body of magnet these lines travel from S-pole to N-pole. This pattern of magnetic field of a bar magnet can also be found by putting the iron fillings around a bar magnet instead of compass needles. The iron filling arrange them in the same pattern as that of compass needle as shown in figure 8.5 (a) and 8.5 (b).

FIGURE 8.5 MAGNETIC FIELD LINES OF A BAR MAGNET

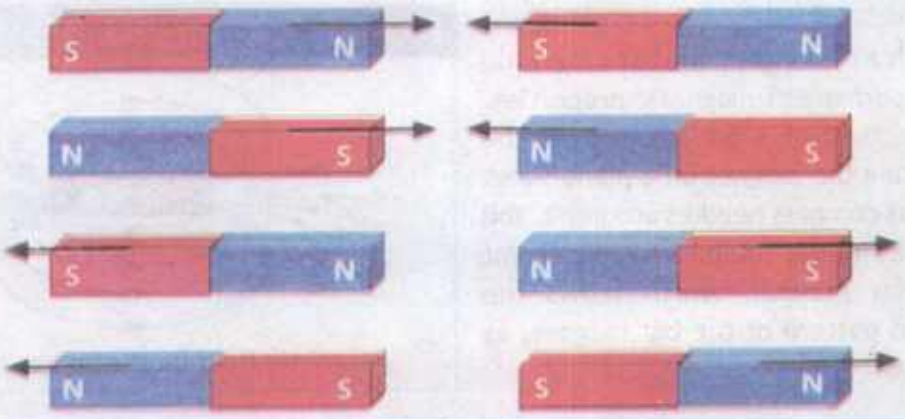


(a) with compass (b) with iron fillings

8.2.2 Direction of magnetic Field at a point:

The magnetic field is the map that we use to describe how the magnetic force is distributed in the space around a magnetic material or magnet and even within a magnetic material or magnet. To find the magnetic field at a point due to some magnet, is determined by placing a north-pole at that point, the force experienced by the north-pole will be the strength of magnetic field at that point. As when we put a test north-pole near the north-pole of material, it repels the test north-pole away from it showing the direction of north-pole of material as outward. The magnetic force is determined by the movement of test magnet as shown in figure 8.6.

FIGURE 8.6 DIRECTION OF MAGNETIC FIELD



8.2.3 Relative Strength of Magnetic Field:

The strength of magnetic field at any point due to a magnetic pole can be found by the field lines.

The field is stronger where the field lines are closer, while the field is weaker where the field lines are farther apart.

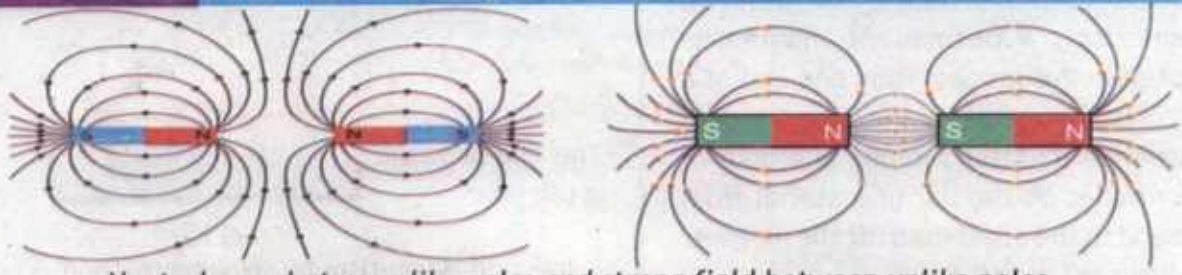


SCIENCE TIDBITS

"The relative strength of a magnetic field is the degree of closeness of the field lines".

Hence magnetic field lines give the direction and the strength of magnetic field. The relative strength of magnetic field due to like poles and unlike poles is shown in figure 8.7. By placing two N-poles close to each other we can decrease the field similarly by placing N-pole near an S-pole we can make magnetic field strengthen.

FIGURE 8.7 LIKE POLES AND UNLIKE POLES



Neutral zone between like poles and strong field between unlike poles

8.2.4 Magnetic Shielding:

There may be different orientation of magnetic field by suitably adjusting the magnets. We can find a field free region called 'neutral zone' by placing two N-poles side by side, such that their field lines seem to repel each other by making a field free region, this phenomenon is called shielding of magnetic field. In daily life we deal with a lot of devices which have to work in strong magnetic environment but this external magnetic field can alter the functioning of the device. So we have to shield the device from external magnetic field.



SCIENCE TIDBITS

Materials used for magnetic shielding are called shields. These materials are used for protecting sensitive circuits from unwanted parasitic magnetic fields including power inverters, magnetic immunity, magnetic sensors and EMI. The commonly used materials as shield are Iron, Nickel and Cobalt. Shields are usually made rounded corners because it is difficult for magnetic field lines to turn an angle of 90°.



8.3 INDUCED MAGNETISM

A material which is not a magnet in normal condition can be made a magnet with the help of some techniques and is called induced magnet and this phenomenon is called induced magnetism. Similarly a magnetic material can lose its magnetization.

FOR YOUR INFORMATION

"A material that becomes a magnet when it is placed in a magnetic field is called induced magnet".

There are many ways to make an object an induced magnet or a magnet to lose its magnetization like, by stroking the material with a magnet, by hammering the material in a magnetic field, by heating or by putting the material inside a coil from which direct current is flowing.

STROKING METHOD: This is the way of aligning the poles of a material by a process called stroking for induced magnetism. A permanent magnet is stroked in this process from one end of a bar of some metal to the other end to magnetize it. After rubbing one pole of the magnet on the bar of material from one end to the other then lift the magnet, as shown in figure 8.8.

FIGURE 8.8 STROKING METHOD



Induced Magnetism by stroking method

HAMMERING METHOD: In this method a bar of metal is placed inside a strong magnetic field and hammered gently. The domains will begin to line up in the direction of applied magnetic field and hence metal bar becomes magnetized. This method is mainly used for magnetization of steel. The magnetization can be increased by heating the metal bar slightly before hammering. This method is shown in figure 8.9.

FIGURE 8.9 HAMMERING METHOD



Induced Magnetism by hammering method

HEATING METHOD: This method is usually used to demagnetize a material, as heat speeds up the movements of already aligned domains which results in misalignment of domains and hence material loses its magnetization. However in recent past scientists have provided the evidences of generating magnetic field by the process of heating. This phenomenon is referred to as the 'magnetic Seebeck effect' or 'thermo-magnetism'.

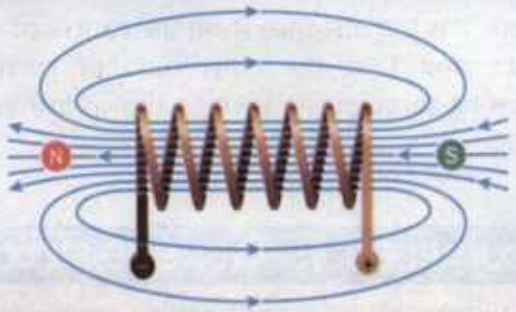
FIGURE 8.10 SOLENOID



SOLENOID: This is the most common method used for the magnetization of metals. A solenoid is a coil of wire wrapped around a cylindrical coil as shown in figure 8.10. The magnetic field of the solenoid resembles with the field of a bar magnet, as shown in figure 8.11. When we wrap a conducting wire (say a copper wire) around a metal with insulation the domains of the metal get aligned. In this process when a current flows through the wire it generates a magnetic field which behaves as external field to the domains of metal placed inside, which aligns the domains. The coil of wire acts as a magnet as long as the current is flowing through it. When current stops it no longer behaves as a magnet. For direct current (DC) the polarity of coil remains the same and hence it magnetizes the material in one direction.

For alternating current the polarity of solenoid changes after every half cycle and hence in first half cycle it magnetizes the material in one direction then demagnetizes it. In second half cycle it magnetizes the material in opposite direction and then demagnetizes it. Materials which easily magnetize and demagnetize are called soft magnetic materials (like soft iron), on the other hand materials which cannot magnetize and demagnetize easily are called hard magnetic materials (like steel).

FIGURE 8.11 MAGNETIC FIELD



Magnetic field of a solenoid

FOR YOUR INFORMATION

Electric motors used in hand-held hair dryers, electric razors, hair trimmers and many more such devices, work with the help of magnetic force. An electric motor generates magnetic field with electric current through the coil. The magnetic force then causes the movement or spinning that runs the motor.



The magnetic field of a solenoid can mathematically be given as: $B = \mu_o n I$ —— 8.1

Here 'B' is the strength of magnetic field having unit tesla (T) which is also equal to newton per ampere per meter ($N A^{-1} m^{-1}$), while μ_o is the permeability of the material (Permeability is the property of a material to its response towards a magnetic field, i.e. how much a material permits magnetic field to pass through it), 'I' is the current flowing through the solenoid and 'n' is the number of turns of the solenoid per unit length given by the relation as,

$$n = \frac{N}{L} \quad \text{—— 8.2}$$

Here 'N' is the total number of turns of the solenoid and 'L' is the length of solenoid. The value of the permeability for vacuum 'μ_o' is given as:

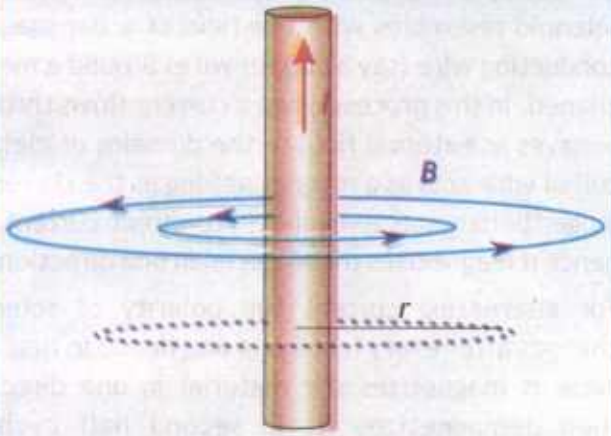
$$\mu_o = 4\pi \times 10^{-7} N A^{-2}$$

Similarly the magnetic field due to a wire carrying current can be given as:

$$B = \frac{\mu_o I}{2\pi r} \quad (8.3)$$

Here 'r' is the distance from the canter of the wire and 'I' is the magnitude of current flowing through the wire as shown in figure 8.12.

FIGURE 8.12 WIRE FIELD



Magnetic field around a wire

EXAMPLE 8.1: MAGNETIC FIELD OF A SOLENOID

A student takes a long straight copper wire (with insulation on it) from his physics lab, he wraps the wire on an iron rod of 50 cm, to make it solenoid of 15 turns. He connects the ends of copper wire with the battery, which provides 1.2 A current. Find the magnetic field he produces in solenoid by doing so.

GIVEN

Length 'L' = 50 cm = 0.5 m

Number of turns 'N' = 50

Current 'I' = 1.2 A

Permeability 'μ_o' = $4\pi \times 10^{-7}$ N/A^2

REQUIRED

Magnetic Field Strength 'B' = ?

SOLUTION

To find magnetic Field Strength we have to find number of turns per unit length first by using equation 8.2

$$n = \frac{N}{L} = \frac{50}{0.5} = 100\,m^{-1}$$

Now using equation 8.1 $B = \mu_o n I$

Putting values: $B = (4\pi \times 10^{-7} N A^{-2})(100\,m^{-1})(1.2A)$

Therefore, $B = 1.5 \times 10^{-4}\ T$ — Answer

FOR YOUR INFORMATION

"Magnetic materials which do not retain their magnetization after removal of external magnetic field or applied current (as in case of solenoid) are called temporary magnets".

8.3.1 TEMPORARY AND PERMANENT MAGNETICS:

The solenoid as stated earlier behaves like a magnet as long as a current flows through it, just after removal of current it loses its magnetic field, hence it is a temporary magnet. It is also called as electromagnet. Electromagnet is type of magnet in which the magnetic field is produced due to an electric current. Examples of temporary magnetics include iron nails, screws, metal bolts, kitchen utensils etc.

FIGURE 8.13 MAGNET TYPES



Examples of permanent magnetic materials include iron ore, cobalt, nickel and Alnico. Temporary and permanent magnets are shown in figure 8.13. Some of the differences are listed below.

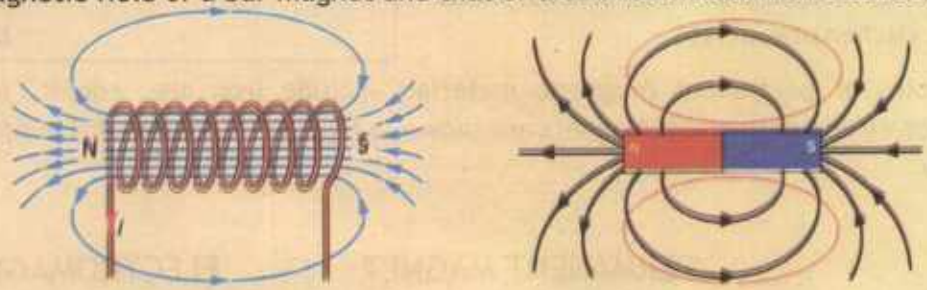
	PERMANENT MAGNET	ELECTROMAGNET
	Permanently magnetized	Temporarily magnetized
	Made of hard magnetic materials	Made of soft magnetic materials
	Magnetism does not vary in strength	Magnetism can be varied in strength according to need
	Magnets' poles can not be altered	Magnets' poles can be changed

8.3.2 USES OF PERMANENT MAGNETS AND ELECTROMAGNETS:

Magnets are used in many fields, depending upon the need we can use permanent or electromagnets. A permanent magnet is made from a material which is magnetized once and does not lose its magnetization by itself and has its own magnetic field. As we know that permanent magnet does not require a continuous supply of electric energy for maintaining its magnetic field. Hence it is used in those applications where continuous supply of electricity is not available or cannot be maintain for long. Although magnetic field strength of permanent magnets are lower than those of electromagnets but they can have magnetic field even in the absence of electricity. Permanent magnets are used in induction cooker, MRI machines, particle accelerators, transformers etc. and in automotive, aerospace, medical, semiconductor and energy industries. Electromagnets are kind of magnets in which the magnetic field is created by an electric current. Electromagnets can be considered as temporary magnets that function only with the flow of electric current, when the current is turned off it loses its magnetization at once.

DO YOU KNOW?

Magnetic field of a bar magnet and that of a coil resembles with each other.



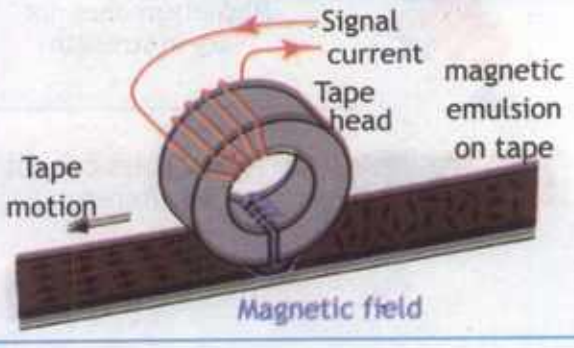
Solenoid Magnet

Electromagnets have a wide range of daily life applications like in electromechanical and electronics devices. Most of the home appliances use electromagnetism as the basic working principle, like electric fan, electric motors and door bells. In medical fields electromagnets are used in MRI scan. Electromagnets are also used in communication devices and power circuits.

8.3.2 APPLICATIONS OF MAGNETS:

A. MAGNETIC RECORDING is a method of saving sounds, pictures and data in the form of electrical signals by the process of selective magnetization of some portion of a magnetic material. For writing the data a magnetic tape head is moved onto the tape which is in motion the magnetic field of the tape head aligns the pattern of magnetic domains according to the applied current flowing through the tape head, as shown in figure 8.14.

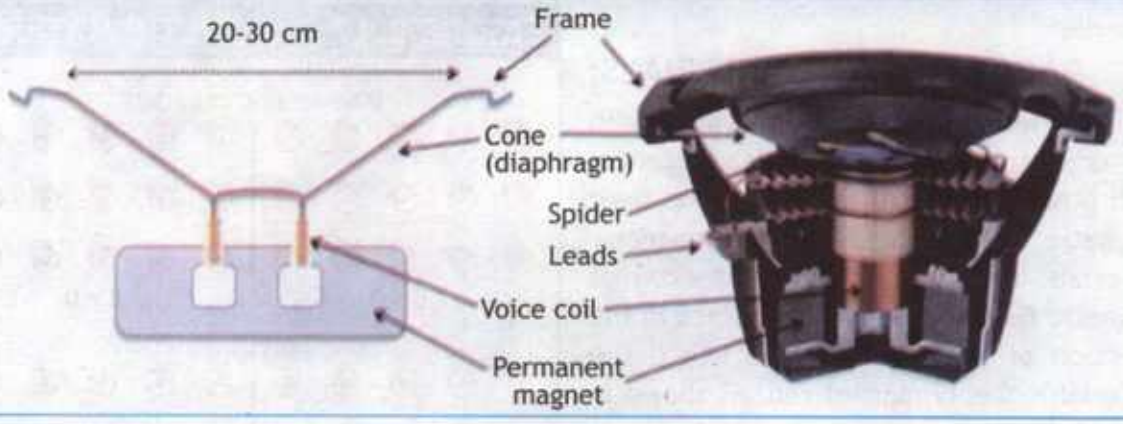
FIGURE 8.14 PROCESS OF MAGNETIC RECORDING



Similarly the reverse process is done for reading the data from the aligned pattern of tape. For magnetic recording the materials commonly used are iron-oxide, cobalt, chromium oxide and pure iron. The main recording media may be a magnetic tape or disk recorders which are used to store and reproduce audio, video signals and computer data. Some other magnetic recording devices are magnetic drum, core and bubble units used for computer storage units.

B. SPEAKERS use magnets in their functioning. To produce sound the speaker need to create some vibrations in the air. This can be done with the help of two magnets one permanent magnet of strong magnetization and the other is electromagnet. The permanent magnet is fixed in the centre of cone (diaphragm), which is a conical structure made up of some flexible material to produce vibrations. An electromagnet is attached at the centre of parmanent magnet which can move to and fro. When the sound singal in the form of electric current flows throuhg the coil of electromagnet it produces alternating magnetic field which due to interaction with field of permanent magnet vibrates it. As the cone is attached to the elctromagnet, with the to and fro motion of electromagnet it vibrates and produces sound. With larger permanent magnet we can produce louder sound. The commonly used material as permanent magnet in speakers is neodymium. The structure of speaker is shown in figure 8.15. Microphones also use magnets in their functioning, but in reverse order. In microphones the cone (diaphragm) vibrates due to sound and hence producing movement in the elctromagnet within the magnetic field of permanent magnet. This produces an electric current which acts as the signal for the speaker.

FIGURE 8.15 ANATOMY OF SPEAKER



C. DOOR LOCKS also use magnets in their working. They have an electromagnet fixed at the door frame and a metal plate fixed with the door, in such a way that when the door is closed the metal plate connects with the electromagnet, as shown in figure 8.16.

When the current passes through the electromagnet it attracts the metal plate with huge force, so that to open door is difficult. When we have to open the door we disconnect the current flowing through electromagnet which releases the metal plate. As this door requires electricity for its functioning it is mainly used for emergency exits at hotels, offices and residential buildings.

FIGURE 8.16 MAGNETIC DOOR LOCK



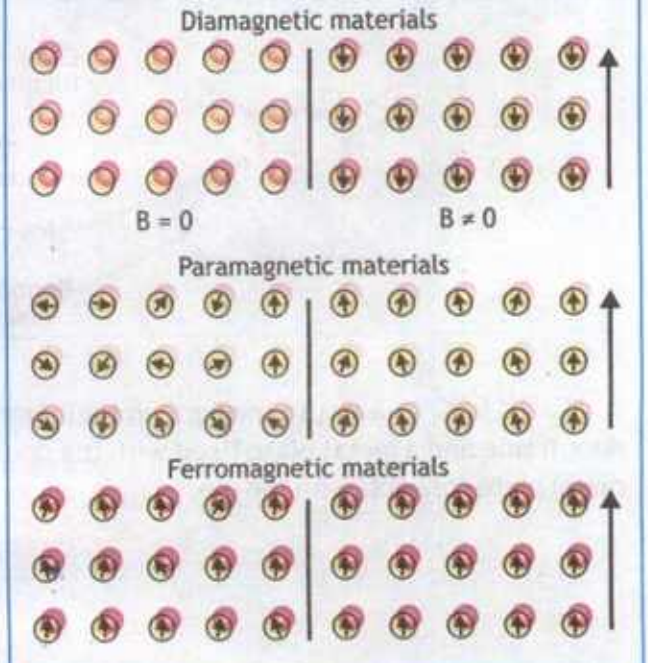
8.4 TYPES OF MAGNETIC MATERIALS

On the base of behavior of materials to the applied external magnetic field, they are classified into three types, i.e. diamagnetic, paramagnetic and ferromagnetic materials.

A. DIAMAGNETIC MATERIALS: Materials in which the spin and orbital motions of electrons are so oriented that they cancel each other's effect and the net magnetic field at a single atom level becomes zero, such materials are called diamagnetic materials. They are slightly repelled by a magnetic field and do not retain the magnetic properties when the external field is removed. Their magnetic field intensity is very small and opposite to the external magnetic field, as shown in figure 8.14. Examples of diamagnetic materials are cooper, zinc, bismuth, silver, gold, marble, water, glass and wood etc. Such materials which have zero magnetic field (B=0) in the absence of external field are called non- magnetic or diamagnetic material.

B. PARAMAGNETIC MATERIALS: Materials which have electrons, whose spin and orbital axis cannot completely cancel each other, in spite of it they add up their magnetic field, are called paramagnetic materials. On the application of external magnetic field they align themselves in the direction of applied field and hence the material is feebly magnetized, as shown in figure 8.17. They experience weak attraction to magnets. Their magnetic field intensity is small and along the direction of external magnetic field. Examples of paramagnetic materials are tungsten, aluminum, lithium and sodium etc. Such materials which have non-zero magnetic field (B≠0) in the absence of external field are called magnetic material.

FIGURE 8.17 MAGNETIC MATERIALS



C. FERROMAGNETIC MATERIALS: Materials which have a net magnetism at the atomic level, even in the absence of external magnetic field, are called ferromagnetic materials. When placed in external field these materials are strongly magnetized in a direction parallel to the applied field and hence they are strongly attracted to a magnet. They retain their magnetization even after removal of applied magnetic field, as shown in figure 8.14. Their magnetic field intensity is very large and along the direction of external magnetic field. Examples of these materials include iron, cobalt, nickel and some metallic alloys.

8.4.1 DIFFERENCE BETWEEN MAGNETIC AND NON-MAGNETIC MATERIALS:

As we studied above that materials are classified as magnetic and non-magnetic on the basis of their response to an applied magnetic field. These differences are summarized in table below.

TABLE 8.1: DIFFERENCE BETWEEN MAGNETIC AND NON-MAGNETIC MATERIALS

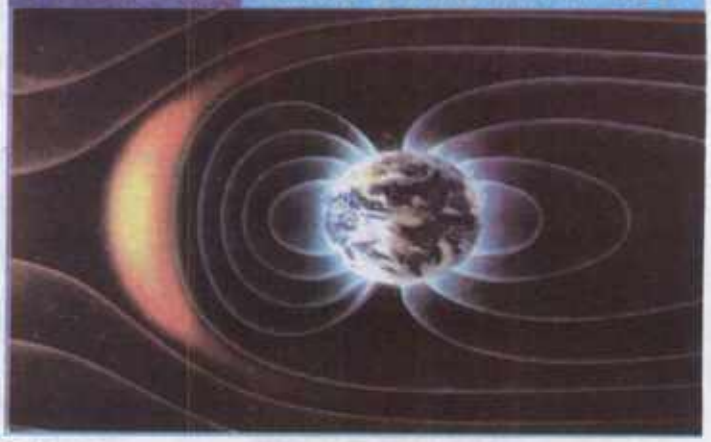
Magnetic Materials	Non-magnetic materials
Materials which are attracted to a magnet are known as magnetic materials	Materials which are not attracted to a magnet are known as non-magnetic materials
The atomic states of a magnetic material are aligned	The atomic states of a non-magnetic material are in random
They respond to a magnetic field	They do not respond to a magnetic field
Magnetic materials have field (magnetic field) around them	Non-magnetic materials do not have field (magnetic field) around them
Magnetic materials can attract and repel other magnetic materials	Non-magnetic cannot attract or repel any magnetic material
Examples of magnetic materials are: Nickel, Cobalt, Steel and Iron.	Examples of magnetic materials are: Rubber, Plastic, Wood and Copper.

8.5 EARTH'S MAGNETIC FIELD

Life exists on our Earth, which is due to many factors, among them the magnetic field is the one. Our Earth is a big magnet and has a magnetic field which is essential for survival of life on it. Do you know from where the Earth gets its magnetic property? As we know that the core of Earth is mainly consists of molten iron, electrical currents flowing in the slowly moving molten iron generate the magnetic field of Earth, called "dynamo effect".

Earth's field is also known as geomagnetic field. The presence of a magnetic field acts like a protective shield around the Earth, which saves life on Earth from harmful cosmic rays coming from the outer space and the charge particles and radiations coming from the Sun. The Earth's magnetic field extends millions of kilometers into the space but have very small magnetic field strength.

FIGURE 8.18 EARTH'S MAGNETIC FIELD

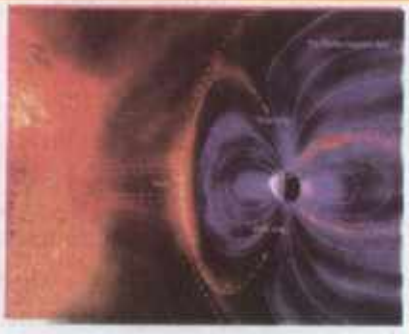


Earth's magnetic field resembles with the field of a bar magnet and is shown in figure 8.18, where from the Sun side the field is pushed a little inside due to continuous striking solar winds consists of radiations and charged particles. The opposite side of the Earth to the Sun, the field is extended several millions of kilometers.



SCIENCE TIDBITS

Aurora (the dancing lights in the sky) at the northern and southern poles of Earth forms due to the magnetic field pattern of Earth. As shown here the charged particles coming from the Sun hit the Earth at poles due to polar cusps of Earth's magnetic field. When these particles enter the atmosphere they ionize the atoms of air (gases) and hence produce light of different colors depending the nature of gas.

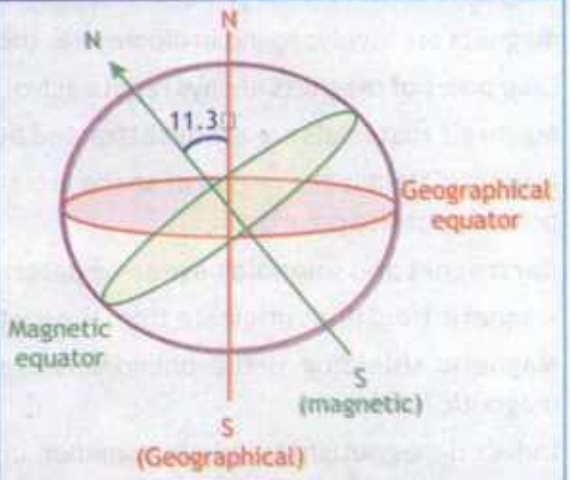


8.5.1 GEOGRAPHICAL AND MAGNETIC POLES OF THE EARTH:

If we look at the map of our Earth we see the poles on it, the north-pole is shown at Arctic and the south-pole is at Antarctic. But these poles on map are the geographical poles of the Earth not magnetic poles of Earth. Our Earth spins about its geographical axis (The line joining the geographical poles of the Earth). The magnetic poles of Earth are inclined at an angle of 11.3° to the geographical poles as shown in figure 8.20.

Hence the compass needle does not point towards the north-pole shown on maps instead it points 11.3° away towards the magnetic pole.

FIGURE 8.20 EARTH'S POLES



Earth's magnetic and geographical poles

8.5.2 BIO-MAGNETISM:

Magnetism plays a vital role in the survival of life on Earth. It also plays a main role in the behavior of many species living on the planet. Like human's heart and brain produce some magnetic fields for their working, without these fields these organs are of no use. These magnetic fields produced by brain and heart are also used for diagnostic techniques.

SCIENCE TIDBITS



In ancient times people use to send messages through pigeons. How they locate their destination to deliver the messages?



Iron crystals are found in the beaks of pigeons. These crystals give the bird a nose for north. Pigeons can sense Earth's magnetic field. With the help of this magnetic navigation pigeons locate their destinations. Similarly some other migrating birds have cryptochrome-4 molecule in their eyes, which is sensitive to the magnetism.

ASSIGNMENT

Draw by yourself the geographical and magnetic poles of Earth. Also draw magnetic field lines and explain why these lines are different from the field lines of a bar magnet.

Similarly some other species use magnetic fields of Earth for different purposes. Migratory animals, birds, see turtles and whales use the magnetic field of Earth to navigate. They use to migrate in spring and autumn or some in winter and summer using the polarity of north and south.

SUMMARY

Magnetic domain is the group of atoms whose N-poles are aligned in the same direction.

Magnets are always found in dipole, i.e. they have a N-pole and a S-pole.

Like poles of magnets always repel each other, while unlike poles attract each other.

Magnetic materials are always attracted by magnets and other magnetic materials.

Magnetic field is the region of space around a magnet in which it is attracted by the magnetic pole of opposite polarity.

Bar magnet and solenoid have same pattern of magnetic fields.

Magnetic field lines originate from the north-pole and end at south-pole.

Magnetic shielding is the phenomenon in which some region of space is made free from magnetic field.

Induced magnetism is the phenomenon in which a material is magnetized by placing it inside an external magnetic field.

Temporary magnets are those magnets which behave like a magnet only in the presence of current.

Permanent magnets are those magnets which behave like a magnet even in the absence of current.

Diamagnetic materials have zero net magnetic fields per atom.

Paramagnetic materials have small net magnetic field per atom.

Ferromagnetic materials have large net magnetic field per atom.

Earth has a magnetic field which resembles with the field of a bar magnet and shield all the life on it from cosmic rays and radiation from the Sun and outer space.

Earth's geographical and magnetic poles are not same but inclined at an angle of 11.3 degrees.

Migrating birds and animals use Earth's magnetic field to navigate.

EXERCISE

MULTIPLE CHOICE QUESTIONS

Q1. Choose the best possible option.

1. If a bar magnet is cut in half it will become
   A. a monopole B. unmagnetized
   C. the same magnet D. magnet of less strength
2. Which one is the quickest method to magnetize a material?
   A. strike with hammer B. moving into magnetic field
   C. Stroking the opposite pole D. putting inside a current carrying coil
3. Earth's magnetic field intensity is:
   A. constant everywhere B. very high at equator
   C. very low at poles D. varies place to place
4. The cause of the Earth's magnetic field is:
   A. rotational motion of Earth B. spinning of Earth
   C. Pull of the Sun D. motion of ions in the core
5. Material which is the best one for making a permanent magnet:
   A. Soft iron B. nickel C. cobalt D. steel
6. Material which is the best one for making an electromagnet:
   A. Soft iron B. nickel C. cobalt D. steel
7. A sensitive magnetic material is to shielded by the external magnetic field. It should be kept inside a box of:
   A. wood B. plastic C. steel D. soft iron
8. Magnetic field lines:
   A. are farthest at poles B. intersect each other
   C. are closed D. do not pass in vacuum
9. When two current carrying wires in the same direction are placed parallel near each other, due to magnetic field produced by each wire they:
   A. repel each other B. attract each other
   C. have no effect on each other D. stop moving the current through them
10. Which of the following material is ferromagnetic?
    A. silver B. copper C. aluminum D. nickel

SHORT RESPONSE QUESTIONS

QII. Give a short response to the following questions

1. Can two magnetic field lines intersect each other? Justify your answer.
2. A freely suspended magnet always points along north-south direction. Why?
3. What is the neutral zone or field free region of the magnetic field?
4. Is there any material which does not have any magnetic behavior? Justify your answer.
5. A proton is also a charged particle and spins like an electron. Why its effect is neglected in study of magnetism?
6. What is the geomagnetic reversal phenomenon? Explain.
7. Why the Earth spins about its geographical axis instead of its magnetic axis? Explain.
8. Why the Earth's geographical and magnetic axis are not coincident? Explain.
9. What is the difference between paramagnetic and ferromagnetic materials?
10. At what factors the strength of the magnetic field of an electromagnet depends?
11. Draw magnetic field lines of two solenoids placed near each other i) facing same poles to each other ii) facing opposite poles to each other

LONG RESPONSE QUESTIONS

QIII. Give a detailed response to the questions given below.

1. Define and explain the magnetism.
2. What is the domain theory of magnetism? Explain.
3. Explain magnetic field strength and magnetic shielding.
4. Explain the magnetic field of a bar magnet and that of a solenoid, also compare them.
5. Define induced magnetism. Also explain some of the methods for induced magnetism.
6. Differentiate between permanent and temporary magnets.
7. Explain some uses of electromagnets and temporary magnets.
8. Explain the three types of magnetic materials.
9. Explain the Earth's magnetic field. Also relate Earth's geographical and magnetic poles.
10. Explain how birds and other migrating animal use Earth's magnetic field to navigate.

NUMERICAL RESPONSE QUESTIONS

QIV. Solve the following.

1. Find the magnetic field due to a wire at 10 cm, if 1.3 A current is passing through the wire.

(Ans. $B = 2.6 \times 10^{-5}$ T)