ICSE
Living Science
Physics

Class 9

Chapter 13 Magnetism

As per the guidelines of NEP 2020

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Living Science Physics

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LEARNING OBJECTIVES

Magnetic and Non-magnetic Substances

- **Induced magnetism by bar magnets**
- **Terms related to a bar magnet**
- **Magnetic induction precedes attraction**

Magnetic Field

- **Magnetic compass**
- **Uniform and non-uniform magnetic fields**

Neutral Points

- **Null points**

Electromagnet

- **Uses of electromagnets**
- **The electric bell**

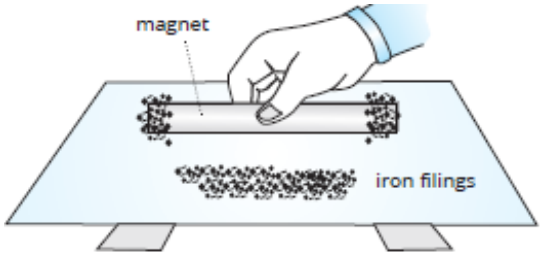
What is a magnet?

A substance which has the property of attracting iron, steel, nickel, etc. and rests in the north-south direction when freely suspended is called a magnet.

The property of attracting iron and steel is known as **magnetism** and the force that the magnet exerts on iron is called the **magnetic force**.

Magnetic and Non-magnetic Substances

Substances which are attracted by a magnet are called **magnetic substances** (more precisely the **ferromagnetic materials**). For example, iron, nickel and cobalt are attracted by a magnet and are, therefore, magnetic substances (ferromagnetic materials). Substances which are not attracted by a magnet are called **non-magnetic substances**. Wood, plastic, brass, aluminium and copper are not attracted by a magnet and are, therefore, non-magnetic substances.

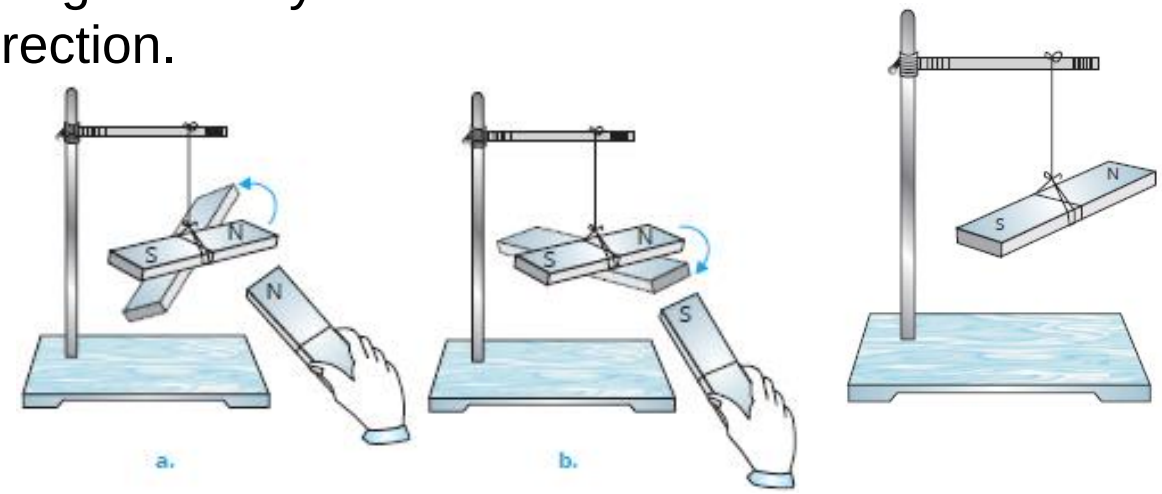


Magnetic properties

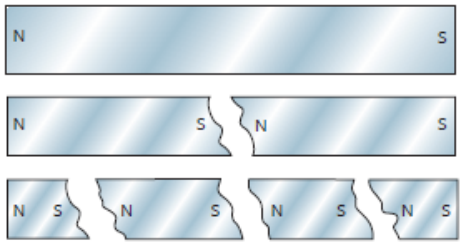
1. Attractive property: A magnet has the property of attracting magnetic substances.

2. Attractive property: A magnet always points in the north-south direction.

3. Attraction and repulsion in a magnet: Like poles of two magnets repel each other unlike poles attract each other.

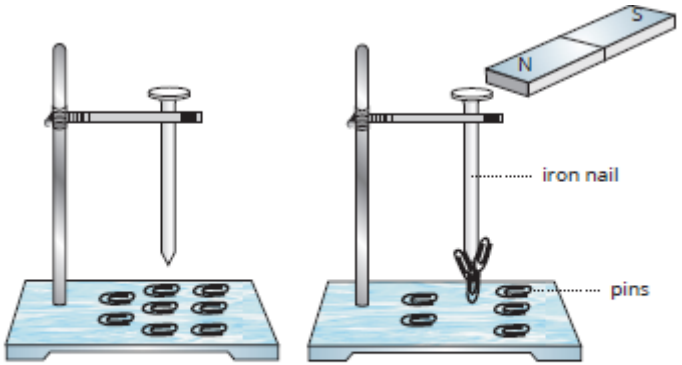


4. Magnetic poles occur in pairs : If a bar magnet is broken into two or more smaller pieces, then, even the smallest piece is a complete magnet. It will have both north and south poles of equal strength



Induced Magnetism by Bar Magnets

The phenomenon by which an ordinary piece of iron (or any magnetic substance) acquires magnetic properties temporarily due to the presence of another magnet near it is called magnetic induction. The magnetism acquired by induction is temporary in nature.



a. The iron nail does not attract the pins.

b. Magnetized iron nail attracts the pins.

The basic properties of a magnet

1. A magnet has the property of attracting magnetic substances.
2. A magnet when freely suspended by a thread comes to rest in the north-south direction.
3. Like poles repel each other and unlike poles attract each other.
4. Magnetic poles always occur in pairs.
5. When a piece of a magnetic substance like iron and steel is placed near a magnet, it acquires magnetism (induced magnetism).

Terms related to a bar magnet

A bar magnet has the following parts:

1. Magnetic poles: The points (N, S) slightly within the ends of a magnet where most of its magnetic power is concentrated are called the poles of the magnet.

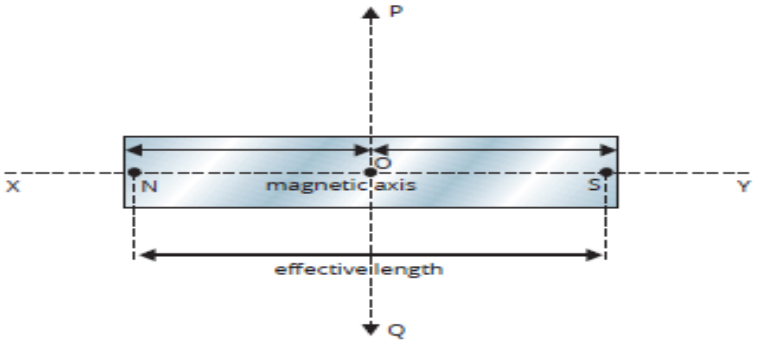
2. Magnetic north pole: The point (N) at the end of the freely suspended bar magnet which points towards north is called the magnetic north pole.

3. Magnetic south pole: The point (S) at the end of the freely suspended bar magnet which points towards south is called the magnetic south pole.

4. Magnetic axis: An imaginary line (XY) passing through the magnetic north and south poles of a bar magnet is called its magnetic axis.

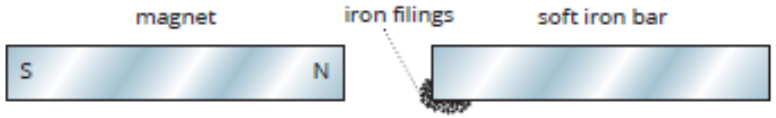
5. Effective length: The distance (NS) between magnetic north pole and magnetic south pole is called the effective length of the magnet.

6. Magnetic equator: An imaginary line (PQ) bisecting the effective length is called the magnetic equator.

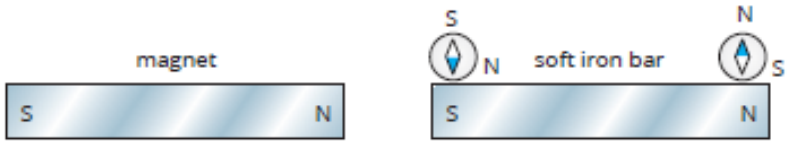


Magnetic induction precedes attraction

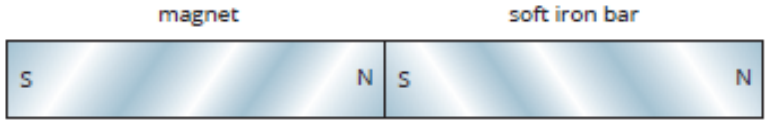
A magnetic pole induces an opposite polarity on the near end and a similar polarity on the farther end of the soft iron bar.



a. Magnetic induction



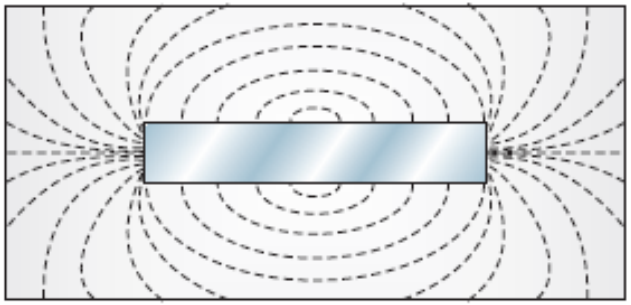
b. Magnetic pole induces an opposite polarity on the near end and similar polarity on the farther end of the soft iron bar.



c. Induction precedes attraction.

Magnetic Field

The space around a magnet within which its effect can be experienced is called magnetic field.

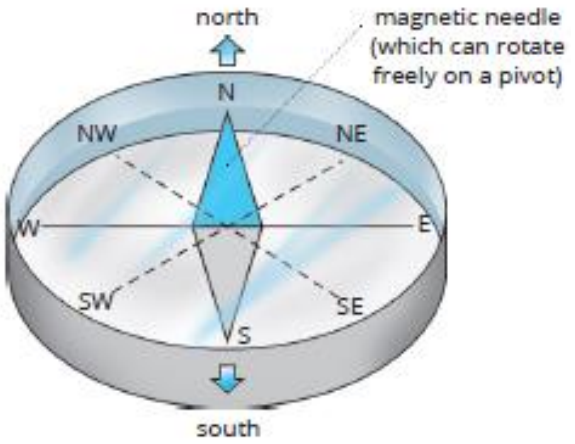


Magnetic lines of force

Magnetic field can be represented with the help of a set of lines called **magnetic field lines** or **magnetic lines of force**.
Magnetic intensity at any point is the force experienced by a unit north pole placed at that point. Magnetic intensity is a vector quantity. The path along which a unit north pole moves in a magnetic field is called the magnetic line of force.

Magnetic Compass

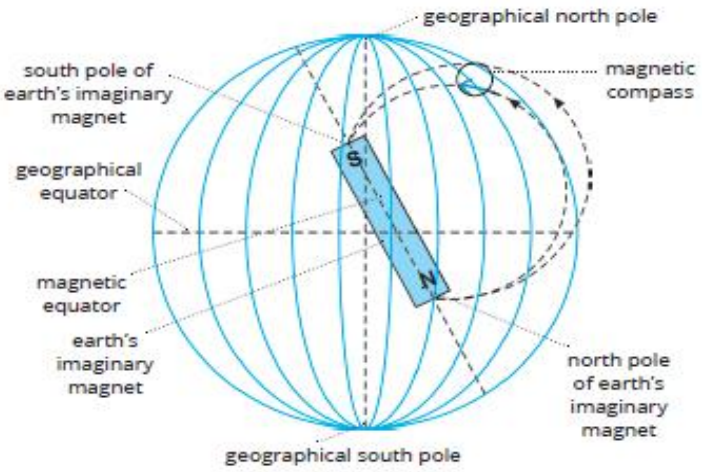
The **magnetic** compass is an instrument having a small magnetic needle which is free to rotate on a pivot (or pin) at the centre of a small round brass or aluminium box with a glass top. The base of the box is marked with directions.



The pointed end of the magnetic compass is the north pole of the compass needle and it always points towards the north of the earth. Sailors, travellers and navigators use magnetic compass to find directions. The Chinese are believed to be the first to have used magnetic compass for navigation.

The Earth's Magnetic Field

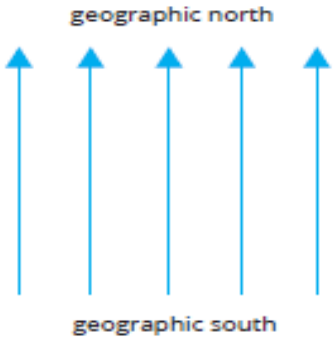
It is now known that our planet earth also shows magnetism. **It is the magnetic force of earth's magnetism which acts on a freely suspended bar magnet and makes it point in the north-south direction.**



Similarly, it is the earth's magnetic field which makes the magnetic needle of a compass to always point towards the north of earth. The earth behaves like a giant magnet present along its diameter. The south pole of the earth's imaginary magnet is in the direction of geographic north pole. The north pole of the earth's imaginary magnet is in the direction of geographic south pole.

Uniform Magnetic Fields

The magnetic field in a region is uniform if it has the same magnetic intensity and the same direction at all points in the region. Parallel equispaced straight lines represent **uniform magnetic field.**

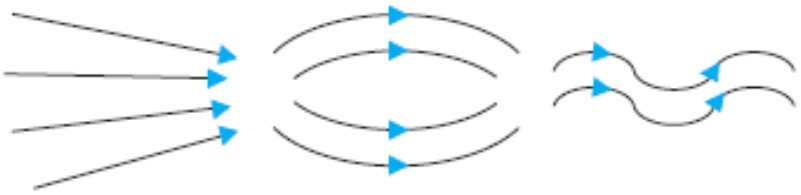


Lines of uniform magnetic field

For example, the earth's magnetic field is uniform. This means that the magnitude and direction of magnetic intensity at every point on the earth's surface is nearly the same.

Non-Uniform Magnetic Fields

The magnetic field in a region is non-uniform if it has different magnetic intensities at different points in the region The converging, diverging or un-equispaced lines represent non-uniform magnetic field.



Lines of non-uniform magnetic field

The closely spaced lines represent a strong magnetic field whereas widely spaced lines represent a weak magnetic field. For example, magnetic field of a bar magnet is nonuniform.

Neutral Point

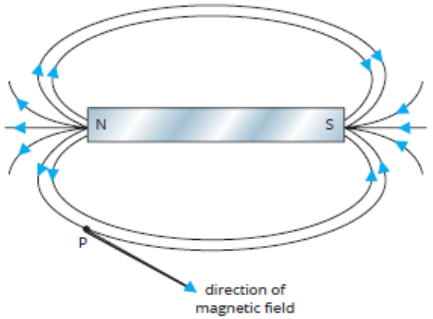
At a certain point near the magnet, the field due to the magnet is equal in magnitude but opposite in direction to the horizontal component (H) of the earth's magnetic field. Such a point is called a neutral point. Therefore, the resultant magnetic field at neutral point will be zero.

Null point

When two magnets are made to face each other, both of them experience their own magnetic fields. **A null point is a point where the magnetic field due to a magnet is completely neutralised due to the other magnet.** Here, the horizontal component of the earth's magnetic field still remains constant, both in magnitude as well as direction, at a given place.

Properties of magnetic lines of force

1. Each line is a closed and continuous curve.
2. These lines are directed from north pole to south pole outside the magnet and from south pole to north pole inside the body of the magnet.



3. The lines are crowded near the magnetic poles where the magnetic field is strong and are far apart near the middle of the magnet where the magnetic field is weak.
4. The tangent at any point on the magnetic field line gives the direction of magnetic field at that point
5. Two magnetic lines of force do not intersect each other. If two magnetic lines of force intersect, there would be two directions of magnetic field at the same point which is not possible.

6. The magnetic lines of force contract longitudinally and widen laterally.
7. Although magnetic lines of force are not real, yet they represent a magnetic field which is real.

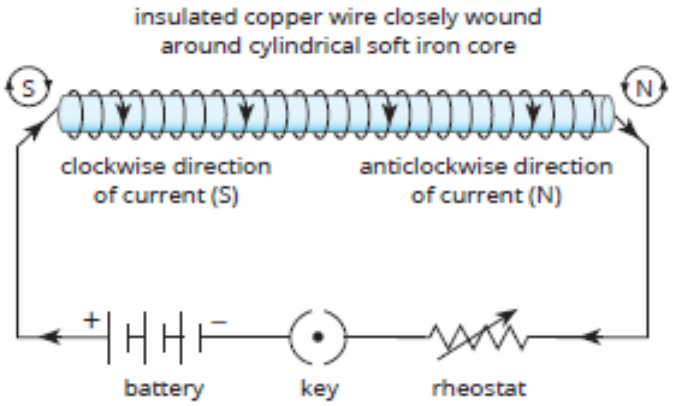
Uses of magnets

1. Magnets are used in magnetic compass, pencil boxes, soap stands, refrigerator doors, etc.
2. Magnets are also used in cycle dynamos, loudspeakers, electric motors and telephones.
3. Ceramic magnets are used in large computers.
4. Magnetic tapes are used in tape recorders and video recorders.
5. Magnets are used in the construction of certain toys to give a magic effect.
6. Magnets are used in the Maglev trains. These types of trains work on the repulsive force of the magnets.

Electromagnet

An electromagnet is a type of magnet in which the magnetic field is produced by the flow of electric current. For making electromagnet, wound several circular turns of insulated copper wire closely in the shape of a cylindrical tube. This is called a solenoid.

For increasing the magnetic field, a soft iron core is put inside the solenoid. **Thus, an electromagnet is a solenoid with a soft iron core.** An electromagnet shows magnetic properties only as long as electric current flows through the solenoid. It loses the magnetic properties as the current is switched off.



This is because soft iron has less retentivity. Retentivity is referred to as the capacity of a material to retain magnetic property in itself.

Uses of electromagnets

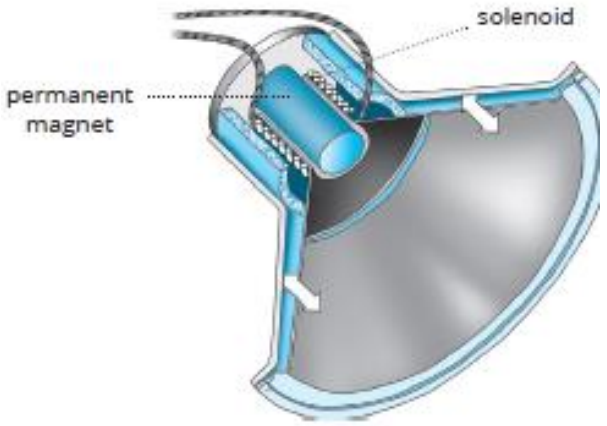
1. Electromagnets are used in the construction of a large number of electrical devices like electric bells, loudspeakers, electric motors, electric fans and telephone instruments.

2. Electromagnets are used to lift and transport heavy loads like big machines, steel girders and scrap iron objects for loading and unloading purposes. Unloading of goods is done by switching off the current in the electromagnet.

3. Electromagnets are used to separate magnetic substances like iron and steel from the nonmagnetic heap of metal scrap.

4. In accidental cases, they are used for removing pieces of iron from wounds or removing steel splinter from the eye.
5. Electromagnets are used for magnetizing steel bars.

a. used in scrap yard to lift ferrous metals

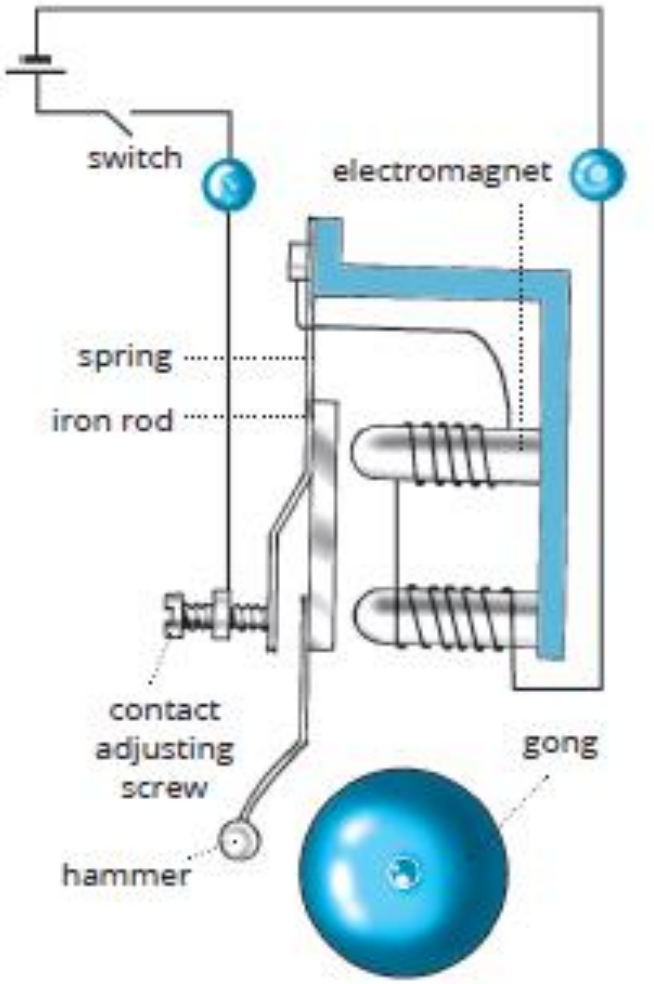


b. cut-away view of loudspeaker

The electric bell

The most common application of an electromagnet is in an electric bell. It consists of an electromagnet, an armature, a contact adjusting screw, a gong and a hammer. The armature consists of a soft iron rod mounted on a spring. One end of the iron rod presses against the top of the contact adjusting screw.

When the switch is pressed on, current flows in the electromagnet. It then attracts the iron rod towards itself, causing the hammer to strike the gong. At the same time, the armature loses contact with the screw and the current is switched off. This causes the electromagnet to lose its magnetism
and the armature springs back to its original position to close the circuit once again. Current flows again and the cycle repeats itself till the current is switched off.



Note: Refer to Table 13.1 for Differences between an electromagnet and a permanent magnet

SUMMARY

1. Magnet: A substance which has the property of attracting magnetic substances and rests in the north south direction when suspended freely is called a magnet.

2. Properties of a magnet:

- It attracts magnetic substances. It comes to rest in the north-south direction when suspended freely.
- Like poles repel each other and unlike poles attract each other. Magnetic poles always occur in pairs. It induces magnetism in magnetic substances.

3. Magnetic induction: The phenomenon by which any magnetic substance acquires magnetic properties temporarily due to the presence of a magnet near it is called magnetic induction.

4. Magnetic field: The space around a magnet within which its effect can be experienced is called its magnetic field.

5. Magnetic lines of force: The path along which a unit north pole moves in a magnetic field is called the magnetic line of force.

6. Uniform magnetic field: The magnetic field in a region is uniform if it has the same magnetic intensity and the same direction at all points in the region. Parallel, equispaced straight lines represent uniform magnetic field.

7. Non-uniform magnetic field: The magnetic field in a region is non-uniform if it has different magnetic intensities at different points in the region. The converging, diverging and unequispaced lines represent non-uniform magnetic field.

8. Neutral point: A point near a magnet where the magnetic field due to the magnet is completely neutralised by the horizontal component of the earth's magnetic field is called a neutral point.

9. Null point: A point where the magnetic field due to a magnet is completely neutralised due to another magnet is called a null point.

10. Electromagnet: It is a solenoid with soft iron core.