

Electricity and Magnetism, Definition, Comparison, UPSC Notes

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Electricity and magnetism come from electric charges and magnetic fields. We see them in everyday things like static electricity and moving currents, as well as in magnets. Together, they make electromagnetism, which is important in technology, transportation, and medicine.

For example, they help generate power, run motors, and even make medical tools like MRI machines work.

Electricity Overview

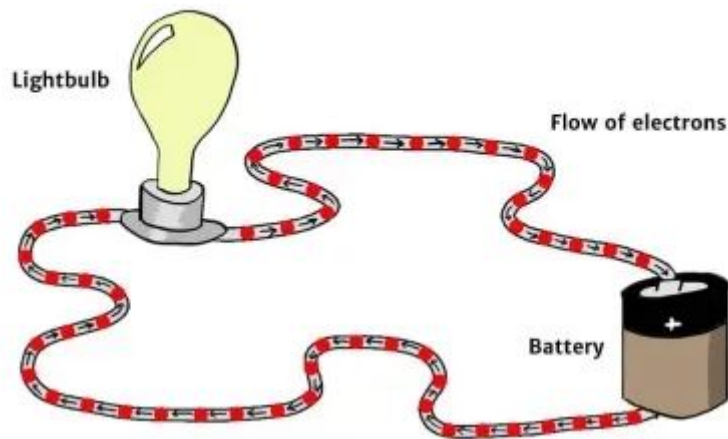
Electricity is a physical phenomenon that is caused by the **presence** and **movement** of electric charges. It manifests itself in a variety of ways, such as **static electricity**, **electric currents**, and **electromagnetic fields**.

- In most electrical processes, **electrons** are the main carriers of electric charge.
- **Ions** (charged atoms or molecules) can transport electric charge in some instances, particularly in **solutions or gases**.

Types of electricity

- **Static:** Static electricity is a **buildup of electric charge** on a surface caused by **friction** and remains stationary until released, like the shock from touching a doorknob after walking on a carpet.
- **Current:** It is the flow of electric charge through a conductor, like electrons moving through a wire. It can be alternating (AC) or direct (DC) current.
 - **Alternating current (AC)** is a flow of electric charge that **periodically reverses direction**.
 - **Direct current (DC)** is a flow of electric charge in a **constant direction**, normally produced by **batteries**.

Electricity Electron



Types of Materials

Conductors, insulators, and semiconductors are the materials essential in electronics, with conductors like copper allowing easy flow of electricity, insulators like rubber preventing it, and semiconductors like silicon enabling controlled conductivity.

Property	Conductors	Insulators	Semiconductors
Electrical resistivity	- Low	- High	- Intermediate
Ability to conduct electricity	- High	- Low	- Intermediate

Applications of Electricity

Electricity plays a key role in modern society, powering everything from household equipment to large plants. In recent years, it has played a significant role in transforming vehicles from fossil fuel-based to clean energy.

- **Residential and commercial applications:** Electricity is necessary in homes and businesses for **running equipment**.
- **Transportation: Electric vehicles (EVs)**, which include are becoming more popular due to their efficiency and low environmental impact.
- **Communication:** Electrical power is required for **data centres, transmission towers, and networking equipment**.

- **Medical industry:** Important for running diagnostic equipment such as **MRI machines, X-ray machines,** and **patient monitoring systems.**
- **Manufacturing industry:** From powering machinery to managing automation systems in manufacturing plants electricity is required.
- **Computers and electronics:** **Electricity powers personal computers, cellphones, tablets,** and other **electronic devices.**

Magnetism Overview

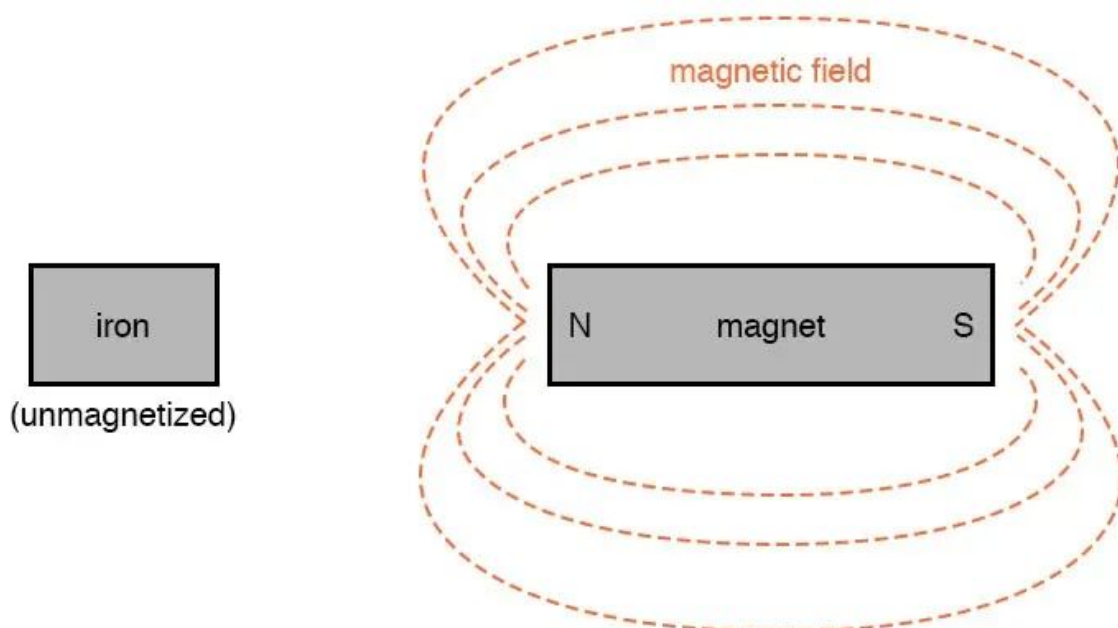
Magnetism is a phenomenon related to magnetic fields that form as electric charges move. This motion can take various forms, including an electric current in a **conductor**, charged particles moving through space, or electron mobility in an **atomic orbital**.

- **Magnetic fields** cause the deflection of moving charges and exert torques on other magnetic objects.
- **Sources of magnetism:** Electric current loops and orbiting electrons, which have a magnetic dipole moment and resemble small bar magnets in an external magnetic field, generate magnetic fields.

Magnetic Properties of Matter

The **magnitude** and **alignment** of dipole moments have an impact on susceptibility, which determines the magnetic properties of matter. The magnetic materials, based on their behaviour in magnetic fields, are classified into three types.

- **Diamagnetic materials:** **Bismuth** and **copper**, are magnetised in the opposite direction of an external magnetic field, resulting in a **repulsive effect** when subjected to a weak magnetic field.
- **Paramagnetic materials:** **Aluminium** and **oxygen**, for example, are attracted by an **external magnetic field** and create internal induced magnetic fields, resulting in a weak attraction.
- **Ferromagnetic materials:** Such as **iron, cobalt,** and **nickel**, have a **high positive sensitivity** to an external magnetic field and can maintain it once it is removed.



Applications of Magnetism

Magnetism has multiple applications in diverse fields of **commerce**. The **various alloys of nickel, cobalt, and iron** are some of the materials with great magnetic qualities; thus, they are used in specialised devices.

- **Electric motors and generators:** Magnetism is necessary in **transferring** electrical energy to mechanical energy and vice versa in electric motors and generators.
- **Data storage:** Magnetic storage devices, such as hard drives, employ magnetic fields to store data.
- **Medical imaging: Magnetic Resonance Imaging (MRI)** is a medical imaging technique that generates detailed images of the inside of the body by using powerful **magnetic fields and radio waves**.
- **Magnetic levitation:** This technology lifts and propels vehicles like trains using magnetic repulsion.
- **Compasses:** Traditional compasses use a small **magnetised needle** that aligns with the Earth's magnetic field to **aid navigation**.
- **Electromagnets:** They are used in lifting large metal objects in scrapyards and play an important role in scientific equipment such as **particle accelerators**.
- **Magnetic sensors and devices:** These include devices such as **Hall effect sensors**, which are used for position sensing in **automotive and industrial applications**.
- **Credit cards and security systems:** **Magnetic strips** on credit cards as well as certain security systems store and read data using magnetic fields.

Comparison Between Electricity and Magnetism

The two related terms that are thought to have given origin to the study of **electromagnetism** are electricity and magnetism. It is said that a magnetic field results from current electricity. While electricity is produced by a shifting magnetic field.

The basis for Comparison	Electricity	Magnetism
Basic nature	- Electricity is the result of the flow of charged particles.	- Magnetism is the attractive or repulsive force that arises from the interaction of moving charges.
Caused by	- Static (stationary) and moving charges are capable of causing electricity.	- Specifically arises due to moving charges .
Monopoles	- Electric monopoles, or single charges , exist.	- Only dipoles are observed .
Characteristic feature	- Electricity is an invisible force in nature.	- Magnetism is regarded as a byproduct of electricity .
Associated with	- Electricity is associated with positive and negative charges.	- Magnetism is associated with the north and south poles .

Electricity and Magnetism UPSC PYQs

Question 1: With reference to 'Li-Fi', recently in the news, which of the following statements is/are correct? **(UPSC Prelims 2016)**

1. It uses light as the medium for high-speed data transmission.
2. It is a wireless technology and is several times faster than 'WiFi'.

Select the correct answer using the code given below.

1. 1 only
2. 2 only
3. Both 1 and 2
4. Neither 1 nor 2

Answer: (c)

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