# Magnetic Effect of Current

## Discovery and Explanation

Hans Christian Oersted discovered that an electric current flowing through a wire produces a magnetic field around it. This magnetic field can deflect a nearby compass needle, demonstrating the connection between electricity and magnetism.

## Characteristics of Magnetic Effect

- The compass needle deflects when current flows through a wire.
- The deflection disappears when the current stops.
- Reversing the current direction reverses the needle's deflection.
- Increasing current strength increases the deflection.
- Decreasing current strength decreases the deflection.

## Practical Applications

The magnetic effect of current is used in electric bells, electric motors, fans, loudspeakers, cranes, relays, and MRI machines.

## Electromagnets

An electromagnet is a coil of wire carrying current that behaves like a magnet with north and south poles. The magnetic property disappears when the current is switched off. The strength of an electromagnet can be increased by inserting an iron core, increasing the number of batteries in series, or increasing the number of coil turns.

## Earth's Magnetism

The Earth acts as a giant magnet due to electric currents in its molten core. Its magnetic field protects us by deflecting harmful solar particles.

## Solved Examples

**Example 1:** A compass needle near a wire deflects when current flows. What happens if the current direction is reversed?

**Solution:** Reversing the current reverses the magnetic field direction, causing the compass needle to deflect in the opposite direction.

**Example 2:** How can the strength of an electromagnet be increased?

**Solution:** The strength can be increased by inserting an iron core inside the coil, increasing the number of batteries in series to increase current, or increasing the number of turns in the coil.

## Practice Set

- **Level 1:** What causes the deflection of a compass needle near a current-carrying wire?
- **Level 2:** Explain how an electromagnet works and how its strength can be increased.
- **Level 3:** Describe an application of electromagnets in industry and explain how the magnetic effect is utilized.

## Answer Key

- **Level 1:** The magnetic field produced by the electric current flowing through the wire causes the deflection.

- **Level 2:** An electromagnet is a coil of wire carrying current that produces a magnetic field. Its strength can be increased by inserting an iron core, increasing the current by adding batteries in series, or increasing the number of coil turns.
- **Level 3:** Electromagnets are used in cranes to lift heavy iron objects. When current flows through the coil, it creates a magnetic field that magnetizes the iron core, allowing it to attract and lift metal objects. Turning off the current releases the objects.

## Heating Effect of Current

### Explanation

When electric current passes through a conductor, it encounters resistance which converts electrical energy into heat. This is known as the heating effect of electric current.

### Applications

This effect is used in household appliances like electric heaters, irons, immersion water heaters, electric kettles, toasters, and geysers. The heating element in these devices is a coil or rod with higher resistance than copper wire, which heats up when current flows.

### Industrial Use

High-temperature electric furnaces use the heating effect to melt metals like iron in steel industries.

### Useful and Wasteful Heating

The heating effect is useful when heat is the intended output, such as in heaters and toasters. It is wasteful when heat is produced unintentionally, such as in electric fans or incandescent bulbs, leading to energy loss.

### Factors Affecting Heat Generation

- Magnitude of electric current
- Material of the wire
- Thickness of the wire
- Length of the wire
- Duration of current flow

## Solved Examples

**Example 1:** Why does an electric iron get hot when switched on?

**Solution:** The electric current passes through the iron's heating element, which has high resistance. This resistance converts electrical energy into heat, making the iron hot.

**Example 2:** What happens if a wire with low current-carrying capacity is used for a high-wattage appliance?

**Solution:** The wire heats up excessively due to high current, which can damage plugs, sockets, and may cause fire hazards.

## Practice Set

- **Level 1:** What is the heating effect of electric current?
- **Level 2:** Name two household appliances that use the heating effect of current.
- **Level 3:** Explain why using wires with low current capacity for high-power devices is dangerous.

## Answer Key

- **Level 1:** The heating effect of electric current is the production of heat when current passes through a conductor due to resistance.
- **Level 2:** Electric iron and electric heater.
- **Level 3:** Wires with low current capacity heat up excessively when high current passes through, which can damage electrical components and cause fire hazards.

## Batteries

### Voltaic Cells

A voltaic cell (galvanic cell) produces electricity from chemical reactions between two different metal electrodes and an electrolyte solution. Common metal pairs include zinc-copper and zinc-silver. Electrolytes can be lemon juice, sulphuric acid, or salt solutions.

### Dry Cells

Dry cells are widely used batteries with a paste electrolyte instead of liquid. They consist of a zinc container (negative terminal), a graphite rod (positive terminal), and a paste electrolyte. Dry cells are typically single-use.

### Rechargeable Batteries

Rechargeable batteries can be reused multiple times by reversing the chemical reactions through charging. Examples include lead-acid batteries (used in cars), nickel-cadmium batteries (used in emergency lights), and lithium-ion batteries (used in phones and laptops). Rechargeable batteries eventually wear out after about 1000 charge cycles.

## Solved Examples

**Example 1:** What is the main difference between a dry cell and a voltaic cell?

**Solution:** A dry cell uses a paste electrolyte and is portable and convenient, while a voltaic cell uses a liquid electrolyte and is less convenient for everyday use.

**Example 2:** Why are rechargeable batteries preferred over dry cells in some applications?

**Solution:** Rechargeable batteries can be used multiple times, reducing waste and cost over time.

## Practice Set

- **Level 1:** What is an electrolyte in a battery?
- **Level 2:** Name two types of rechargeable batteries and their common uses.
- **Level 3:** Explain why dry cells are called 'use-and-throw' batteries.

## Answer Key

- **Level 1:** An electrolyte is a substance (liquid or paste) that allows the flow of electric charge inside a battery.
- **Level 2:** Lead-acid batteries (used in cars) and lithium-ion batteries (used in phones and laptops).
- **Level 3:** Dry cells are called 'use-and-throw' because they cannot be recharged and must be discarded after use.

## Quick Reference Table

## Common Mistakes and Misconceptions

## Glossary