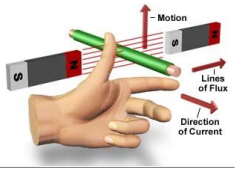
Electricity and Magnetism



Electromagnetism

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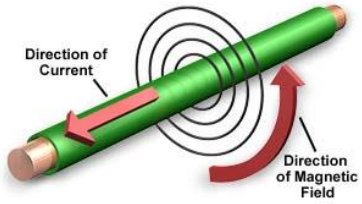
Introduction

In this topic we are going to discuss the following:

- Definition of an electromagnet.
- The force on a current carrying conductor.
- Fleming's left-hand rule.
- Application of Fleming's left-hand rule.
- Applications of electromagnets.



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Electromagnet

- An electromagnet is a type of magnet that creates magnetic field **only** when electric current flows through it.
- To create a simple electromagnet, do the following:
  a. Wrap a wire around a soft iron core to form a coil.
  b. Pass electric current through the coil.
  c. As the current is following, the iron core becomes magnetized.
  d. The magnetic field produced by the magnet will disappear as soon as current is turned off.

- **Figure 1** below shows a simple electromagnet.

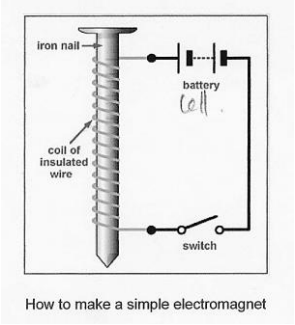

Figure 1

Force on a conductor in a magnetic field of bar magnets

- When a current carrying conductor is placed in a magnetic field, a **force** (**F**) acts on it.
- This is also called the **motor effect**.
- A current is flowing through a conductor it creates its own magnetic field around the wire.
- When this current carrying conductor is placed in an external magnetic field, the two magnetic fields interact.

- This interaction between the magnetic fields of the current carrying conductor and that of the external magnets produces a **force** on the conductor.
- **Figure 2** below illustrate a current carrying conductor in an external magnetic field.

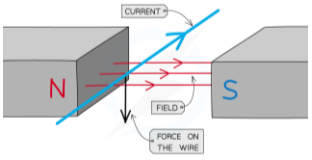

Figure 2

Fleming's Left-Hand Rule

- To find the direction of the force acting on the conductor we use the **Fleming's Left-Hand Rule**.
- Fleming's Left-Hand Rule is a simple method to identify and remember the direction of the force acting on a current carrying conductor in a magnetic field.
- Using this rule, we can also identify the direction of external magnetic field and the direction of current flow in the conductor.

- The statements below illustrate how the Fleming's Left-Hand Rule works,
  a. Hold your left hand so that your thumb, first finger, and second finger are all at **right angles** to each other.
  b. The **First finger** points in the direction of **external magnetic field**.
  c. The **Second finger** points in the direction of **current flow** in the conductor.
  d. The **Thumb** point in the direction of **force** acting on the conductor. (Direction of Motion)

Fleming's Left-Hand Rule

- **Figure 3** below illustrate the Fleming's Left-Hand Rule.

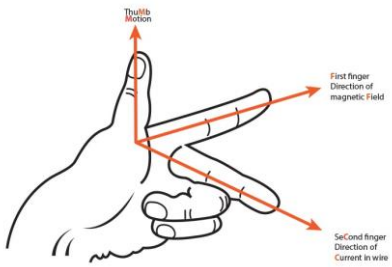

Figure 3

- In simple term we just say:
  a. First Finger = Magnetic field
  b. Second Finger = Current
  c. Thumb = Force/Motion
- Fleming's Left-Hand Rule is applied in the designing of various devices that make use of electromagnets and magnets such as:
  a. Electric motors.
  b. Loud speakers.
  c. Galvanometer.
  d. Electric generators.

Application of Fleming's Left-Hand Rule

Try:

1. **Figure 4** shows a loud speaker, use it to answer questions that follow.

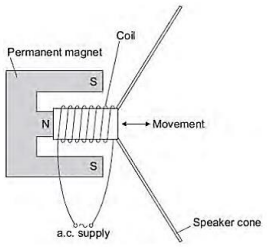

Figure 4

The loud speaker cone vibrates when an alternating current flows through the coil.

a. Explain why? **(4 marks)**

Due to the interaction between the coil's magnetic field and the permanent magnet's field. As the a.c. changes direction, the coil experiences a changing force according to Fleming's Left-Hand Rule, making it move back and forth. This motion vibrates the attached cone, producing sound waves.

Application of Fleming's Left-Hand Rule

Try:

2. **Figure 5** shows a laboratory setup, use it to answer questions that follow:

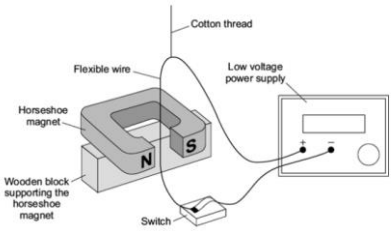

Figure 5

A flexible wire is suspended between the ends of a horseshoe magnet. The flexible wire hangs from a cotton thread. When the switch is closed, the wire kicks forward.

a. Identify the effect which is being demonstrated. **(1 mark)**

b. What effect will the following changes in the setup cause:

   i. More powerful horseshoe magnet is used. **(1 mark)**

   ii. The connection to the power supply are reversed. **(1 mark)**

Applications of electromagnets

The electric bell

- When the bell button is pressed, an electric current flows through a coil, turning it into an electromagnet.
- The electromagnet attracts a metal armature (a small iron strip), causing a hammer to strike the bell and produce sound.
- As the armature moves, it breaks the circuit, turning off the electromagnet.
- The armature springs back, completing the circuit again, and the process repeats rapidly, creating a continuous ringing sound.

Figure 6 below shows a circuit diagram of an electric bell.

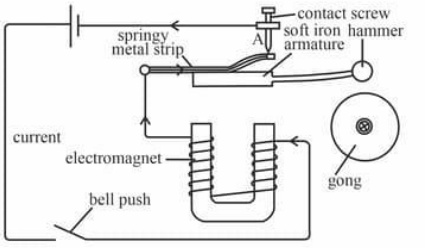

Figure 6

Applications of electromagnets

The telephone receiver

- Electrical signals (representing sound) from the phone line pass through a coil, creating a varying magnetic field in the electromagnet.
- The electromagnet attracts or repels a thin, flexible diaphragm made of metal.
- As the diaphragm vibrates in response to the changing magnetic field, it reproduces the original sound waves, allowing you to hear the other person's voice.

Figure 7 below shows a circuit diagram of an electric bell.

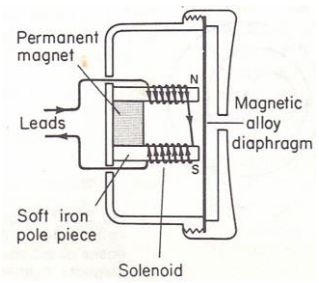

Figure 7

Applications of electromagnets

In your groups, discuss the following applications of electromagnets.

a. Circuit Breakers. (2 marks)

b. Cranes. (2 marks)

c. Data storage. (2 marks)

Next

Electromagnetic Induction