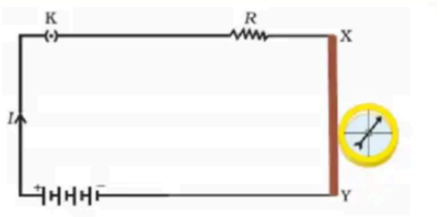
MAGNETISM CLASS X

Magnetic effects of current – **A current carrying conductor always creates a magnetic field around it.**
This is known as magnetic effects of current.
Magnetic effects of current was demonstrated by Hans Christian Oersted by his experiment.

Oersted Experiment

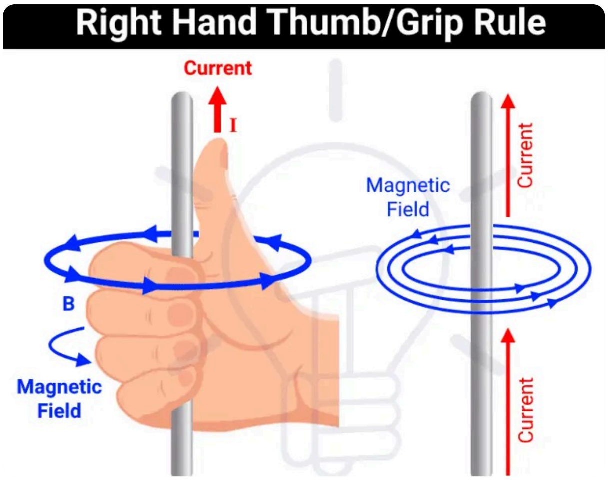


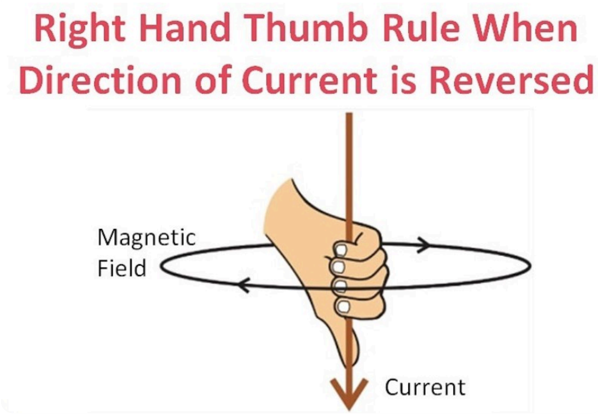
- In 1820, Hans Christian Oersted performed an important experiment which showed that there is a relation between electricity and magnetism.
- When the current is passed through the conductor, a magnetic needle placed close to the conductor deflects indicating the presence of magnetic field around it.
- When the current was switched off, magnetic needle of magnetic compass comes back to original N-S position
- When direction of current was reversed by reversing the terminals of the battery, it was observed that magnetic needle also showed deflection in opposite direction.
- The direction of deflection of the needle is given by **SNOW RULE**

Maxwell's Right Hand Thumb Rule

DEFINATION ***If a straight current-carrying conductor is held in the right hand such that the thumb points in the direction of current, then the curled fingers give the direction of the magnetic field lines around the conductor.***

Maxwell's right-hand thumb rule indicates the direction of magnetic field if the direction of current is known.
According to this rule, if we grasp the current-carrying wire in our right hand so that our thumb points in the direction of current, the direction in which our fingers encircle the wire will give the direction of magnetic field lines around the wire.
When thumb points upwards, the curled fingers are anticlockwise. So, the direction of magnetic field is anticlockwise.
When thumb points downwards, the curled fingers are clockwise. So, the direction of magnetic field is clockwise.





Proper Explanation (Step-by-step)

1. Take a straight current-carrying conductor.
2. Hold it in your right hand.
3. Point your right thumb in the direction of current.
4. The curling of the fingers shows the direction of magnetic field lines around the conductor.

👉 This rule helps us find the direction, not the strength, of the magnetic field

Important Facts Related to the Rule

- It is also called the Right Hand Grip Rule.
- It is applicable only for straight current-carrying conductors.
- Direction of magnetic field reverses when the direction of current is reversed.
- Magnetic field lines are circular around the conductor.

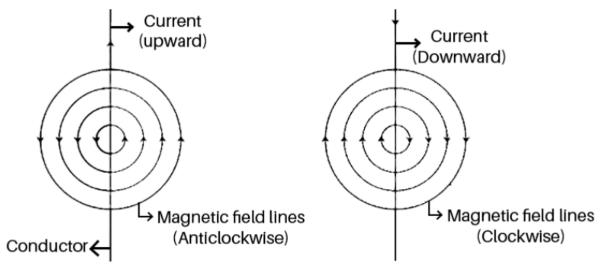
QUESTIONS

Q1. A vertical wire carries current upward Using Maxwell's right hand thumb rule, state the direction of magnetic field on the right side of the wire.

Q2. Why does reversing the direction of current reverse the direction of magnetic field?

Magnetic Field Lines in a Straight Current-Carrying Conductor

Magnetic field lines around a straight current-carrying conductor** are **imaginary concentric circular lines** drawn around the conductor, which show the **direction and strength of the magnetic field produced due to current.** OR **Magnetic field lines due to a straight current-carrying conductor (or moving charges) are imaginary concentric circular lines formed around the conductor, which represent the direction and strength of the magnetic field produced by the moving charges.



Direction of Magnetic Field

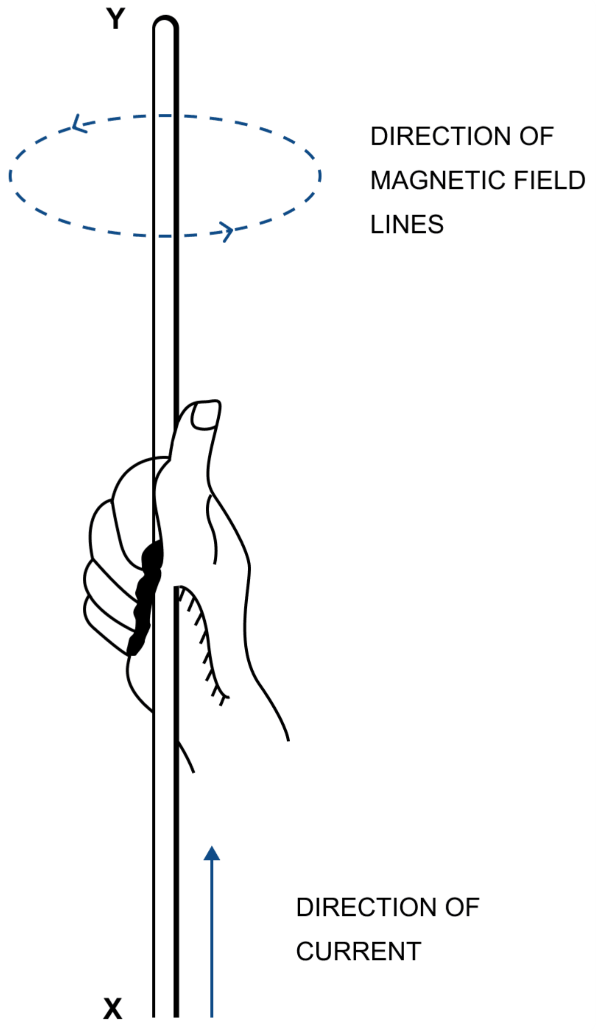
FACTS

- ***Magnetic field lines are concentric circles around the straight conductor.***
- ***The conductor passes through the centre of these circles.***
- ***Direction of magnetic field is given by the Right Hand Thumb Rule.***
- ***Magnetic field is stronger near the conductor (lines are closer).***
- ***Magnetic field decreases with distance from the conductor.***
- ***Reversing the direction of current reverses the direction of magnetic field line***

Q. *State a law, which determines the direction of magnetic field around a current carrying wire.*

Right hand thumb rule is used to determine the direction of magnetic field around a current carrying wire.

Right hand thumb rule, If we hold the current carrying conductor in our right hand such that the thumb points in the direction of flow of current, then the fingers encircle the wire in the direction of the magnetic field lines.



IMP QUESTIONS

Q. Explain the pattern of magnetic field lines around a straight current-carrying conductor

Q. Describe an experiment to show that a current-carrying conductor produces a magnetic field.

Q. State Maxwell's right hand thumb rule and mention one use.

Q. Draw a neat diagram showing magnetic field lines around a straight current-carrying conductor. Explain the pattern.

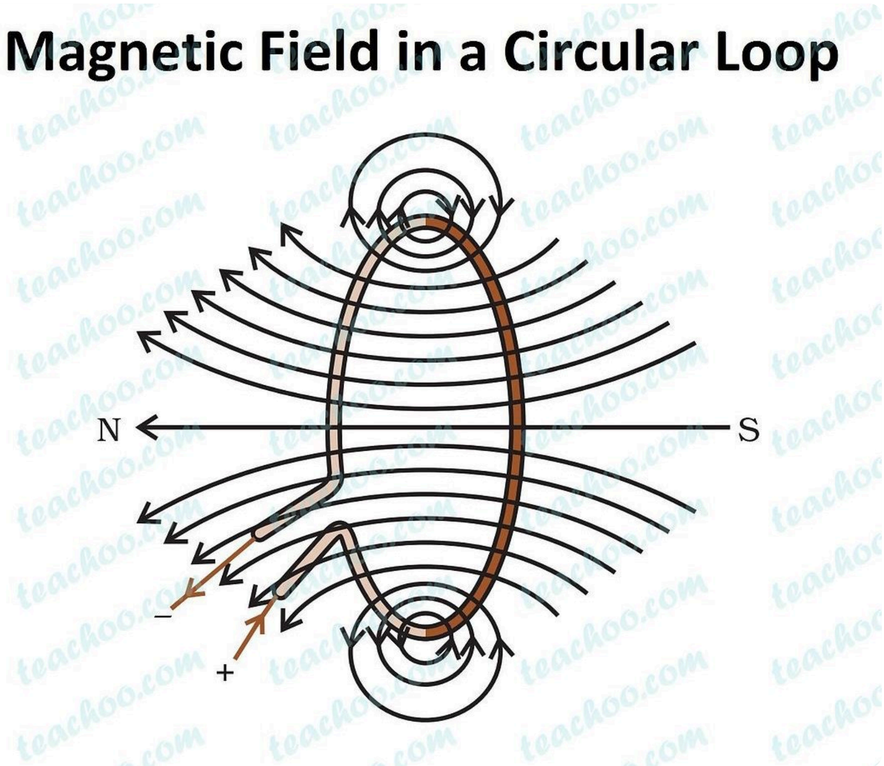
Q. Explain Oersted's experiment. What conclusion can be drawn from it?

Q. Explain how the direction of magnetic field around a conductor depends on the direction of current.

Magnetic Field Due to a Current Through a Circular Loop

The magnetic field due to a current through a circular loop is the magnetic field produced around and inside the loop when electric current flows through it. At the centre of the loop, the magnetic field is strong and nearly uniform

- *Near the wire → magnetic field lines are circular.*
- *Towards the centre → field lines become straight and parallel.*
- *At the centre of the loop → magnetic field is maximum and uniform.*
- *The direction of the magnetic field is given by the Right Hand Thumb Rule*



Q. Clock Face Rule of a Magnet (Clock Rule)

If the direction of current in a circular loop or solenoid appears clockwise when viewed from one face, that face behaves as a South pole. If the current appears anticlockwise, that face behaves as a North pole.

Name and state the rule by which the polarity at the ends of a current carrying solenoid is determined / State and illustrate the rule used for finding the polarity of the faces of a circular coil.

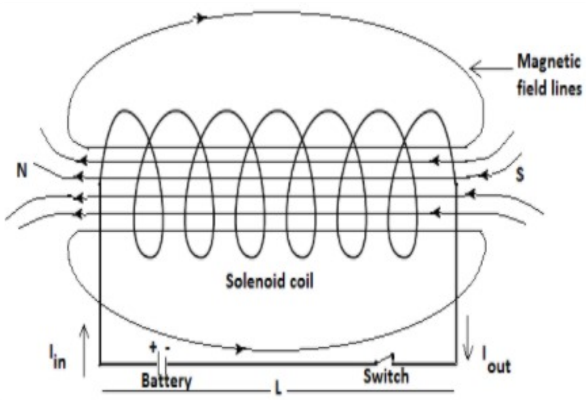
When an observer, looking at the circular coil, finds the current to be flowing in the anti-clockwise direction, then face of the coil behaves like the N-pole of the equivalent magnet. On the other hand, if the current is seen to flow in the clockwise direction, then face of the coil behaves like the S-pole of the equivalent magnet.

Magnetic Field Lines of a Current-Carrying Solenoid

***What is a Solenoid ? A solenoid is a long cylindrical coil made by winding many turns of insulated copper wire closely together.*

Magnetic Field Produced by a Current-Carrying Solenoid

- *When electric current flows through a solenoid, it produces a magnetic field around it.*
- *The magnetic field pattern of a solenoid is similar to that of a bar magnet.*



Factors Affecting the Strength of Magnetic Field of a Solenoid

1. *Current (I)*

→ More current → Stronger magnetic field Number of turns (N)

2. *More turns → Stronger magnetic field*
3. *Nature of core*

   → Soft iron core greatly increases magnetic field strength

Important Facts (Board-Favourite Points)

- *Magnetic field inside a solenoid is uniform.*
- *A solenoid converts electrical energy into magnetic energy.*
- *Soft iron is used as core because it magnetises and demagnetises easily.*
- *Solenoid is used to make electromagnets.*
- *Reversing current reverses the polarity of the solenoid.*

Magnetic Field Line Pattern (Detailed Explanation)

(a) Inside the Solenoid

- *Magnetic field lines are:*
  - *Straight*
  - *Parallel*
  - *Equally spaced*
- *This shows that the magnetic field inside a solenoid is strong and uniform.*

(b) Outside the Solenoid

- *Magnetic field lines are:*
  - *Curved*
  - *Widely spaced*
- *This shows that the magnetic field outside the solenoid is weak.*

On What Factors Does Magnetic Field Depend?

1. Magnitude of Current (I)

- *Magnetic field is directly proportional to current.*
- *More current → stronger magnetic field.*

📌 *Example: Increasing current in a wire increases compass deflection.*

2. Distance from the Conductor (r)

- ***Magnetic field decreases as distance increases from the conductor.***
- ***Field is strongest near the conductor.***

📌 ***Example: Compass near the wire shows more deflection than one farther away.***

3. Shape of the Conductor

- ***Straight conductor → circular magnetic field***
- ***Circular loop → stronger field at centre***
- ***Solenoid → strong and uniform magnetic field***

📌 ***Solenoid produces the strongest magnetic field.***

4. Number of Turns (N) (For loop and solenoid)

- ***More turns → stronger magnetic field.***

📌 ***Used in electromagnets.***

5. Nature of Core (For Solenoid)

- ***Soft iron core greatly increases magnetic field strength.***
- ***Steel is not preferred.***

Fleming's Left-Hand Rule

If the thumb, forefinger and middle finger of the left hand are stretched mutually perpendicular to each other, such that the forefinger points in the direction of magnetic field and the middle finger points in the direction of current, then the thumb gives the direction of force (motion) acting on the conductor.

"Explanation (Easy, Exam-Scoring Language) "

- Stretch the **thumb, forefinger and middle finger** of the **left hand** so that they are **mutually perpendicular**.
- **Forefinger** → Direction of **magnetic field** (North → South)
- **Middle finger** → Direction of **current** (positive → negative)
- **Thumb** → Direction of **force or motion** of the conductor
- Fleming's Left-Hand Rule is used to determine the **direction** of this force.
- This principle is the **basis of an electric motor**.

This rule helps us find the **direction of motion** of a current-carrying conductor placed in a magnetic field.

IMP.

Fleming's Left-Hand Rule is used to find the direction of force (motion) in electric motors. If you know the directions of current and magnetic field, this rule helps you find the direction in which the conductor will move. It is mainly used in devices where electricity creates motion. 1. Shows the direction of force (motion): It is mainly used in electric motors to find the direction in which the conductor will move when placed in a magnetic field and a current flows through it. 2. Three fingers represent three directions: Thumb → Motion (Force) Forefinger → Magnetic Field Middle Finger → Current 3. Used when current is known: This rule helps when we already know the direction of current and magnetic field and need to find the direction of movement. 4. Applies to motors: The Left-Hand Rule is commonly used in devices like fans and motors where electricity is used to create motion

Long Answer (4–5 Marks)

Q. State and explain Fleming's Left-Hand Rule. Mention its application.

Answer: Fleming's Left-Hand Rule states that if the thumb, forefinger and middle finger of the left hand are stretched mutually perpendicular to each other, such that the forefinger points in the direction of magnetic field and the middle finger points in the direction of current, then the thumb gives the direction of force acting on the conductor. This rule is based on the principle that a current-carrying conductor placed in a magnetic field experiences a force. The rule is used to determine the direction of motion of the conductor.

Application:

It is used in finding the direction of rotation in an **electric motor**.

Applying Fleming's Left-Hand Rule in a Current-Carrying Conductor

When Do We Apply the Left-Hand Rule?

We apply Fleming's Left-Hand Rule when a current-carrying conductor is placed in a magnetic field and we want to find the direction of force (motion) on the conductor.

Step-by-Step Application (Very Important for Exams)

1. *Place the conductor in a magnetic field*
    - *Magnetic field direction is from North to South.*
2. *Ensure current flows through the conductor*
    - *Direction of current is taken from positive to negative terminal.*
3. *Stretch the three fingers of the LEFT hand*

    - *They must be mutually perpendicular to each other.*
4. *Set the fingers correctly*
    - *Forefinger → Direction of magnetic field (N → S)*
    - *Middle finger → Direction of current*
    - *Thumb → Direction of force / motion on the conductor*

Question: A straight conductor is placed between the poles of a magnet. Current flows from left to right. Find the direction of force.

Application:

- *Forefinger → magnetic field (N → S)*
- *Middle finger → current (left → right)*
- *Thumb → direction of force*

Relation Between a Solenoid and a Bar Magnet

Direct Relation (Key Idea)

A current-carrying solenoid behaves like a bar magnet.

Explanation (Board Perspective)

- *When electric current flows through a solenoid:*
    - *One end behaves as a North pole*
    - *The other end behaves as a South pole*
- *The magnetic field pattern around a solenoid is exactly similar to that of a bar magnet.*

Similarities Between Solenoid and Bar Magnet

1. *Both have North and South poles.*
2. *Magnetic field lines:*
    - *Emerge from North pole*
    - *Enter South pole*
3. *Inside both:*
    - *Field lines go from South to North*
    - *Form closed loops*
4. *Both attract magnetic materials like iron.*
5. *Both show maximum magnetic strength at the poles.*

Important Difference (Must Mention in Exam)

Solenoid	*Bar Magnet*
Magnetism only when current flows	*Permanent magnet*

Strength can be changed	*Strength fixed*
Polarity can be reversed by reversing current	*Polarity fixed*

Why a Solenoid Acts Like a Bar Magnet (Reason Question ⭐)

Because the combined magnetic field of all circular current loops in a solenoid produces a field pattern similar to that of a bar magnet.

One-Line Exam Answer (Very Important 🔑)

> *A current-carrying solenoid behaves like a bar magnet because it produces a similar magnetic field pattern with distinct north and south poles.*

HOTS Question (With Answer)

Q: If current in a solenoid is switched off, will it still behave like a bar magnet? Why?
Ans: No, because the magnetic field of a solenoid exists only when current flows, whereas a bar magnet is permanent.

"Magnetic field is directly proportional to current" (CBSE / ICSE Class 10)

Statement

The strength of the magnetic field (B) produced by a current-carrying conductor is directly proportional to the electric current (I) flowing through it.
$B \propto I$

Explanation (Simple, Exam-Scoring Language)

- *When current flows through a conductor, it produces a magnetic field around it.*
- *If the current is increased, the magnetic field becomes stronger.*
- *If the current is decreased, the magnetic field becomes weaker.*
- *This happens because a larger current means more moving charges, which produce a stronger magnetic effect.*

Experimental Evidence (Mention in Answers)

- *In Oersted's experiment, increasing the current in the wire causes greater deflection of the compass needle.*
- *This shows that magnetic field strength increases with current.*

Mathematical Form (For Clarity)

At a fixed distance from the conductor:
$B = kI$

where

- *B = magnetic field strength*
- *I = current*
- *k = constant (depends on the medium and distance)*

One-Line Reason Answer (Very Important 🔑)

> *Magnetic field is directly proportional to current because an increase in current increases the number of moving charges, producing a stronger magnetic field.*

Magnetic Field is Directly Proportional to Current

(With Numerical + Link to Conductor, Loop & Solenoid)

1. Board-Style Statement (2–3 Marks)

At a fixed distance from a current-carrying conductor, the strength of magnetic field (B) is directly proportional to the current (I) flowing through it.

$B \propto I$

This means:

- *If current increases → magnetic field increases*
- *If current decreases → magnetic field decreases*

2. Numerical-Based Question (CBSE Pattern)

Question

The current flowing through a straight conductor is 2 A and the magnetic field produced is 4 × 10^{-5} T.
Find the magnetic field when the current is increased to 6 A (distance remains same).

Step-by-Step Solution (How Students Should Write)

Given:

$I_1 = 2A$

$B_1 = 4 \times 10^{-5} T$

$I_2 = 6A$

Since,

$B \propto I \; \frac{B_1}{I_1} = \frac{B_2}{I_2} \; B_2 = \frac{B_1 \times I_2}{I_1} \; B_2 = \frac{4 \times 10^{-5} \times 6}{2} \; B_2 = 12 \times 10^{-5} T$

Answer

The magnetic field becomes 12 × 10^{-5} T.

3. Linking This Relation to Important Cases (Very Important for Theory Questions)

(a) Straight Current-Carrying Conductor

- *Magnetic field strength increases when current increases.*
- *Shown by greater deflection of compass needle.*

(b) Circular Current-Carrying Loop

- *Magnetic field at the centre:*
  - *Increases with increase in current*
  - *Increases with number of turns*

(c) Solenoid

- *Magnetic field inside a solenoid:*
  - *Directly proportional to current*
  - *Becomes very strong when current is large*
- *This is why solenoids are used to make electromagnets.*

4. HOTS Question (With Answer)

HOTS

Why does increasing current in a solenoid make it a stronger electromagnet?

Answer

Increasing current increases the number of moving charges, which strengthens the magnetic field inside the solenoid. Hence, the electromagnet becomes stronger.

5. One-Line Exam Answer (Must Remember 🔑)

> *Magnetic field is directly proportional to current because an increase in current increases the magnetic effect of moving charges.*

Ultra-Quick Memory Trick 🧠

"Current ↑ ⇒ Magnetic field ↑"

On What Factors Does Magnetic Field Depend?

(CBSE / ICSE Class 10 – Magnetic Effects of Electric Current)
The strength of magnetic field produced by a current-carrying conductor depends on the following factors:

1. Magnitude of Current (I)

- *Magnetic field is directly proportional to current.*
- *More current → stronger magnetic field.*

📌 *Example: Increasing current in a wire increases compass deflection.*

2. Distance from the Conductor (r)

- *Magnetic field decreases as distance increases from the conductor.*
- *Field is strongest near the conductor.*

📌 *Example: Compass near the wire shows more deflection than one farther away.*

3. Shape of the Conductor

- *Straight conductor → circular magnetic field*
- *Circular loop → stronger field at centre*
- *Solenoid → strong and uniform magnetic field*

📌 *Solenoid produces the strongest magnetic field.*

4. Number of Turns (N) (For loop and solenoid)

- *More turns → stronger magnetic field.*

📌 *Used in electromagnets.*

5. Nature of Core (For Solenoid)

- *Soft iron core greatly increases magnetic field strength.*
- *Steel is not preferred.*

One-Line Exam Answer (Very Important 🔑)

> *The magnetic field depends on the magnitude of current, distance from the conductor, shape of the conductor, number of turns, and nature of the core.*

Quick Revision Table

Factor	*Effect on Magnetic Field*
Current	*↑ Current → ↑ Field*
Distance	*↑ Distance → ↓ Field*
Turns	*↑ Turns → ↑ Field*
Core	*Soft iron → strong field*

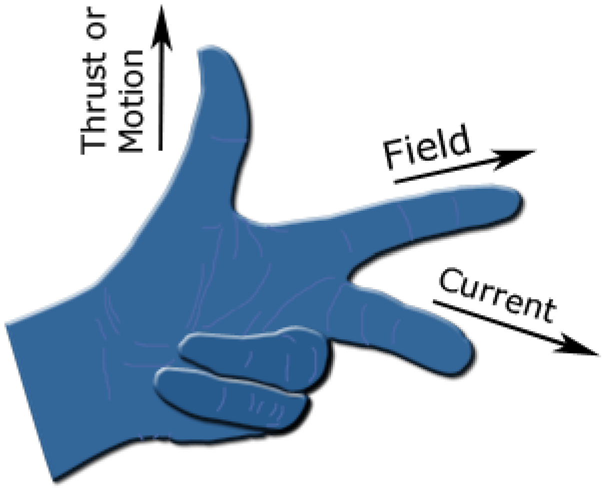
Common Board "Why" Question

Q: Why does magnetic field decrease with distance?

A: Because magnetic field lines spread out as distance increases.

Fleming's Left-Hand Rule

(Class 10 – Magnetic Effects of Electric Current)



1. Standard Definition

Fleming's Left-Hand Rule states that:

> *If the thumb, forefinger and middle finger of the left hand are stretched mutually perpendicular to each other, such that the forefinger points in the direction of magnetic field and the middle finger points in the direction of current, then the thumb gives the direction of force (motion) acting on the conductor.*

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2. Explanation (Easy, Exam-Scoring Language)

- *Stretch the thumb, forefinger and middle finger of the left hand so that they are mutually perpendicular.*
- *Forefinger → Direction of magnetic field (North → South)*
- *Middle finger → Direction of current (positive → negative)*
- *Thumb → Direction of force or motion of the conductor*

This rule helps us find the direction of motion of a current-carrying conductor placed in a magnetic field.

3. Scientific Law Involved (Motor Principle)

Statement (Board-Standard)

> *When a current-carrying conductor is placed in a magnetic field, it experiences a mechanical force.*

- *Fleming's Left-Hand Rule is used to determine the direction of this force.*
- *This principle is the basis of an electric motor.*

4. Conditions / Limitations (Important for Exams)

1. *The conductor must be carrying current.*
2. *The conductor must be placed in a magnetic field.*
3. *The directions of current and magnetic field must be perpendicular.*
4. *This rule gives only the direction of force, not its magnitude.*
5. *Not applicable if the conductor is parallel to the magnetic field.*

5. Applications (Mention Any One in Exam)

- *To find the direction of motion in an electric motor*
- *In DC motors*
- *In loudspeakers and electrical measuring instruments*

6. Short Answer (2–3 Marks)

Q1. State Fleming's Left-Hand Rule.

Answer:
Fleming's Left-Hand Rule states that if the thumb, forefinger and middle finger of the left hand are held mutually perpendicular, with the forefinger in the direction of magnetic field and the middle finger in the direction of current, then the thumb gives the direction of force acting on the conductor.

Q2. What does Fleming's Left-Hand Rule help us determine?

Answer: It helps to determine the direction of force or motion of a current-carrying conductor placed in a magnetic field.

Long Answer (4–5 Marks)

Q. State and explain Fleming's Left-Hand Rule. Mention its application.

Answer: Fleming's Left-Hand Rule states that if the thumb, forefinger and middle finger of the left hand are stretched mutually perpendicular to each other, such that the forefinger points in the direction of magnetic field and the middle finger

points in the direction of current, then the thumb gives the diction of force acting on the conductor.

This rule is based on the principle that a current-carrying conductor placed in a magnetic field experiences a force. The rule is used to determine the direction of motion of the conductor.

Application: It is used in finding the direction of rotation in an electric motor.

8. Common Mistakes to Avoid (Exam Alert ⚠️)

- ❌ *Using right hand instead of left*
- ❌ *Writing "direction of magnetic field" instead of "direction of force"*
- ❌ *Forgetting perpendicular arrangement*
- ❌ *Mixing with Fleming's Right-Hand Rule (generator rule)*

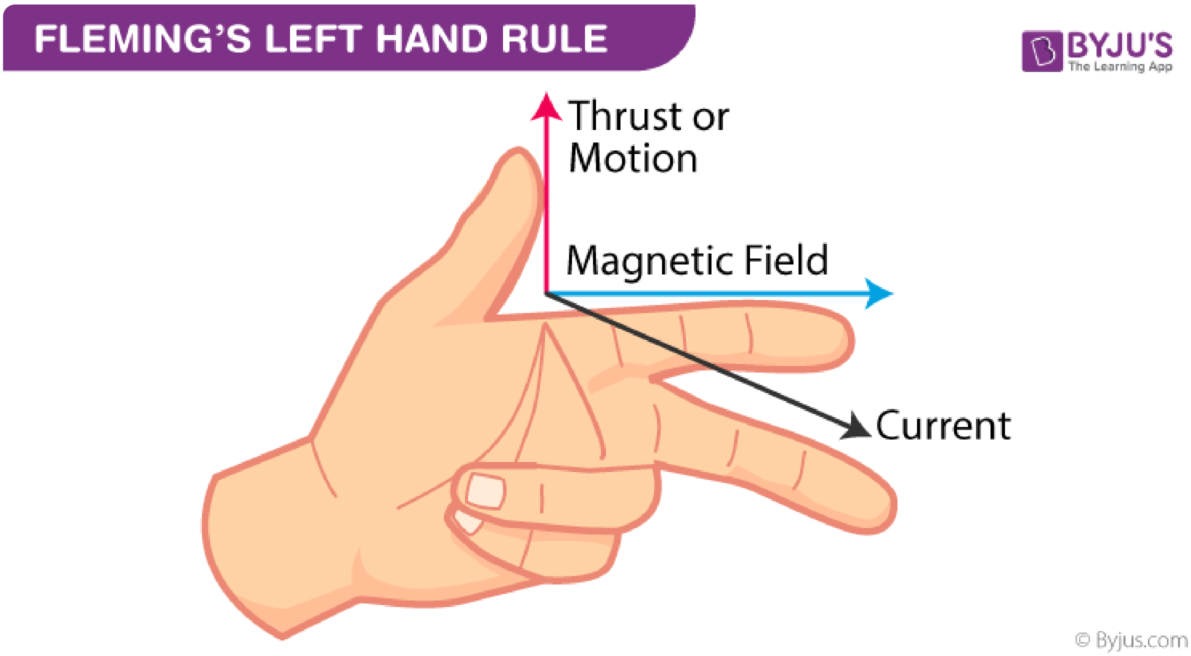
9. One-Line Revision Key 🔑

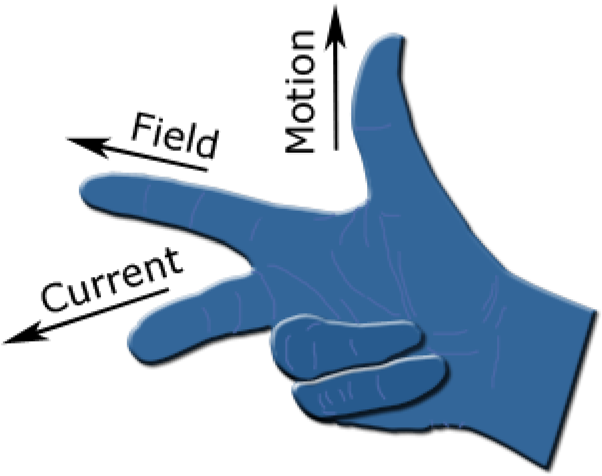
"Left hand → Force, Motor.

Compare Fleming's Left-Hand Rule vs Right-Hand Rule

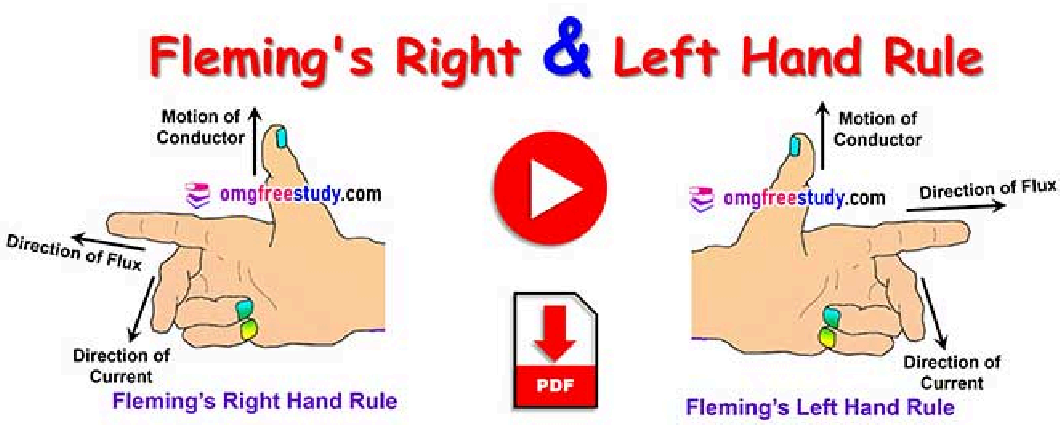
Here is a clear, board-exam–ready comparison of Fleming's Left-Hand Rule and Fleming's Right-Hand Rule for CBSE / ICSE Class 10, written in simple, scoring language.

Comparison: Fleming's Left-Hand Rule vs Fleming's Right-Hand Rule





DC Generator



Meaning (One-Line Recall)

- *Left-Hand Rule → Used to find direction of force (motion)*
- *Right-Hand Rule → Used to find direction of induced current*

Comparison Table (Most Important for Exams)

Basis	*Fleming's Left-Hand Rule*	*Fleming's Right-Hand Rule*
Hand used	*Left hand*	*Right hand*
Also called	*Motor rule*	*Generator rule*
Used to find	*Direction of force / motion*	*Direction of induced current*
Principle	*Magnetic effect of current*	*Electromagnetic induction*
Application	*Electric motor*	*Electric generator*
Thumb indicates	*Force / motion*	*Motion of conductor*
Forefinger indicates	*Magnetic field (N → S)*	*Magnetic field (N → S)*
Middle finger indicates	*Current*	*Induced current*
Main use in syllabus	*Motors*	*Generators*

Scientific Principles Involved

Left-Hand Rule

> *A current-carrying conductor placed in a magnetic field experiences a force.*

Right-Hand Rule

> *When a conductor moves in a magnetic field, an electric current is induced in it.*

2–3 Mark Board Answer (Ready-to-Write)

Fleming's Left-Hand Rule is used to determine the direction of force acting on a current-carrying conductor placed in a magnetic field, whereas Fleming's Right-Hand Rule is used to determine the direction of induced current when a conductor moves in a magnetic field.

4–5 Mark Board Answer Tip

- *Draw two small diagrams*
- *Label thumb, forefinger, middle finger*

- *Mention motor for left hand*
- *Mention generator for right hand*

Common Confusion to Avoid (Exam Alert ⚠️)

- ❌ *Left hand ≠ current direction finder*
- ❌ *Right hand ≠ force direction finder*
- ✅ *Left → Force (Motor)*
- ✅ *Right → Current (Generator)*

Memory Trick 🧠 (Very Effective)

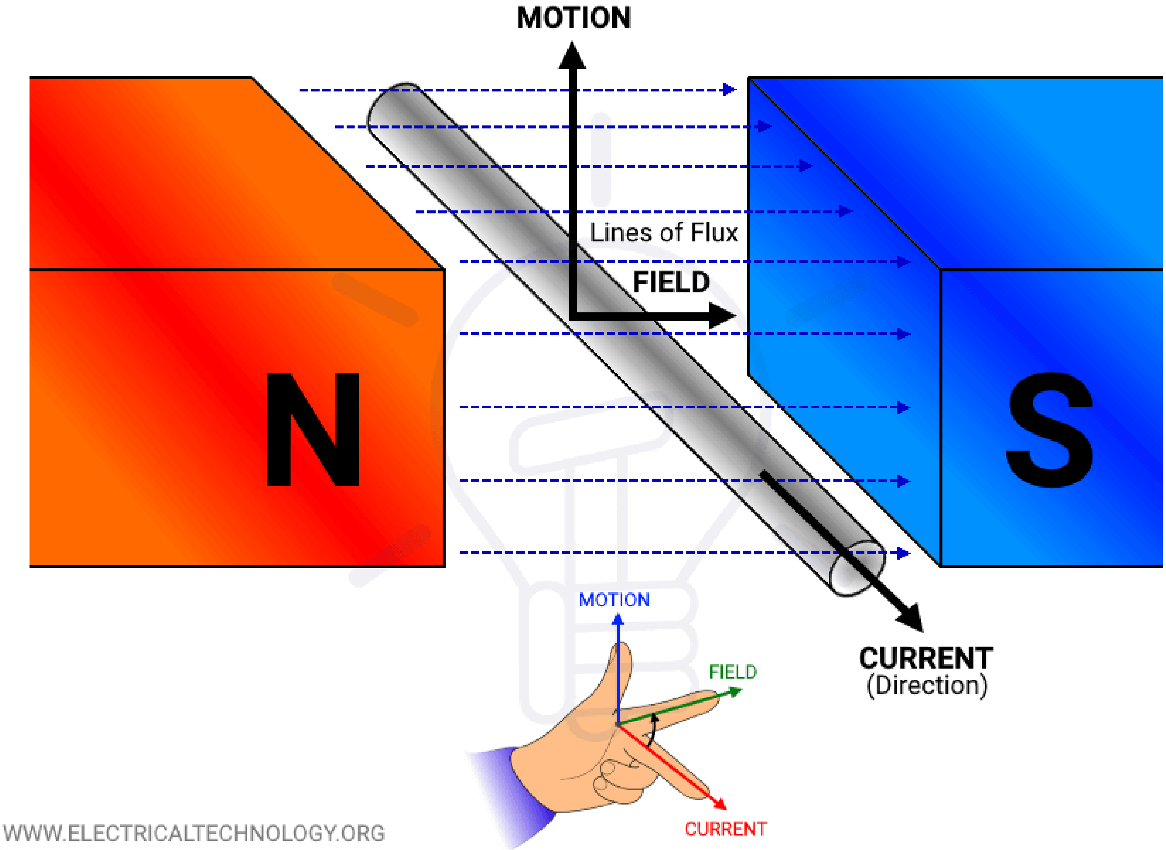
"Left = Lift (Force), Right = Run (Current)"

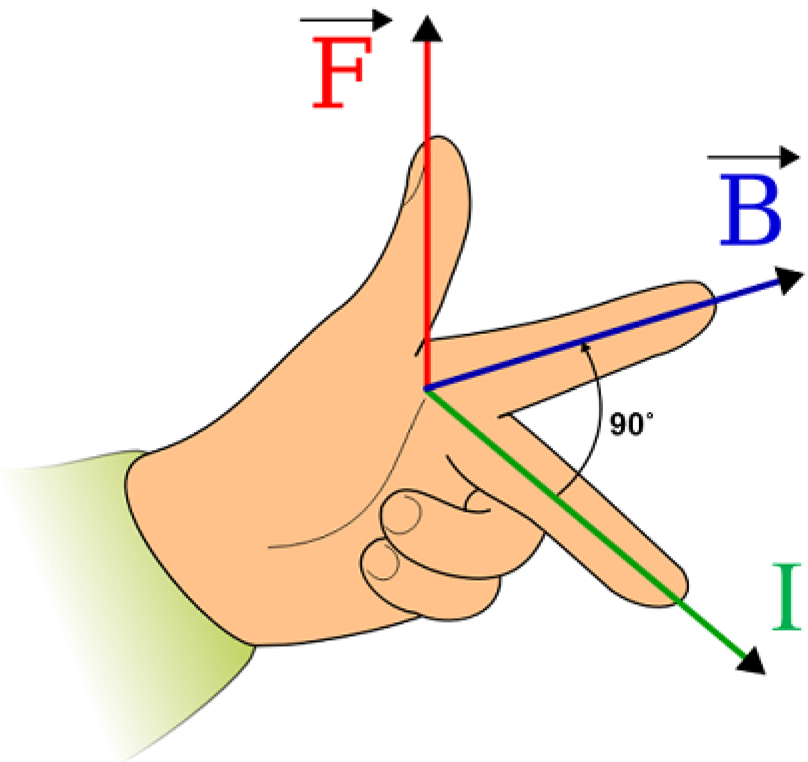
APPLYING LEFT HAND RULE IN A CURRENT CARRYING CONDUCTOR

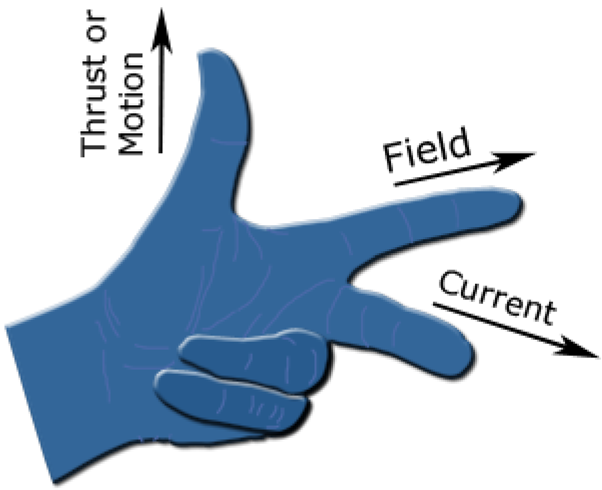
Applying Fleming's Left-Hand Rule in a Current-Carrying Conductor

(CBSE / ICSE Class 10 – Exam-Scoring Explanation)

Fleming's Left Hand Rule for Motors







When Do We Apply the Left-Hand Rule?

We apply Fleming's Left-Hand Rule when a current-carrying conductor is placed in a magnetic field and we want to find the direction of force (motion) on the conductor.

Step-by-Step Application (Very Important for Exams)

1. *Place the conductor in a magnetic field*
   - *Magnetic field direction is from North to South.*
2. *Ensure current flows through the conductor*
   - *Direction of current is taken from positive to negative terminal.*
3. *Stretch the three fingers of the LEFT hand*
   - *They must be mutually perpendicular to each other.*
4. *Set the fingers correctly*
   - *Forefinger → Direction of magnetic field (N → S)*
   - *Middle finger → Direction of current*
   - *Thumb → Direction of force / motion on the conductor*

👉 *The thumb gives the required answer.*

What Does the Rule Tell Us?

- *The direction in which the conductor moves.*
- *It does not give the magnitude of force.*

Simple Example (Board-Style)

Question: A straight conductor is placed between the poles of a magnet. Current flows from left to right. Find the direction of force.

Application:

- *Forefinger → magnetic field (N → S)*
- *Middle finger → current (left → right)*

- *Thumb → direction of force*

Answer: The conductor moves in the direction shown by the thumb.

Conditions to Apply the Rule (Write Any Two)

- *Conductor must be current-carrying*
- *Magnetic field must be present*
- *Current and magnetic field must be perpendicular*

Where Is This Used? (1-Line Application)

- *To find the direction of rotation in an electric motor.*

One-Line Exam Answer 🔑

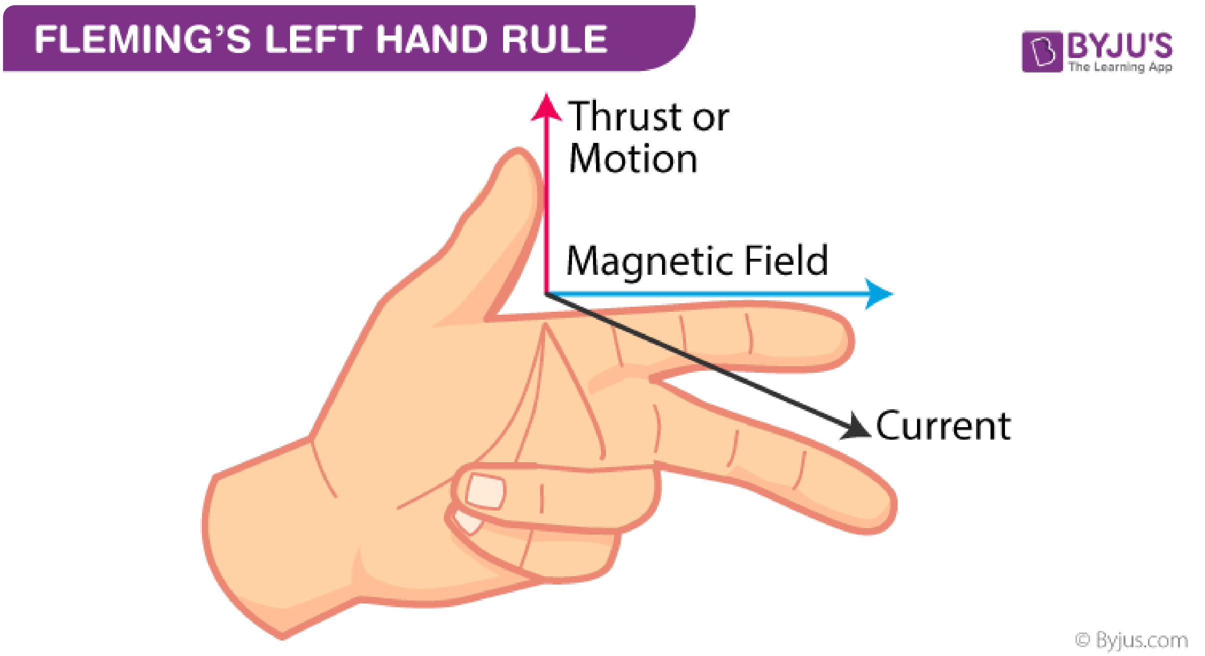
> *Fleming's left-hand rule is applied to determine the direction of force on a current-carrying conductor placed in a magnetic field.*

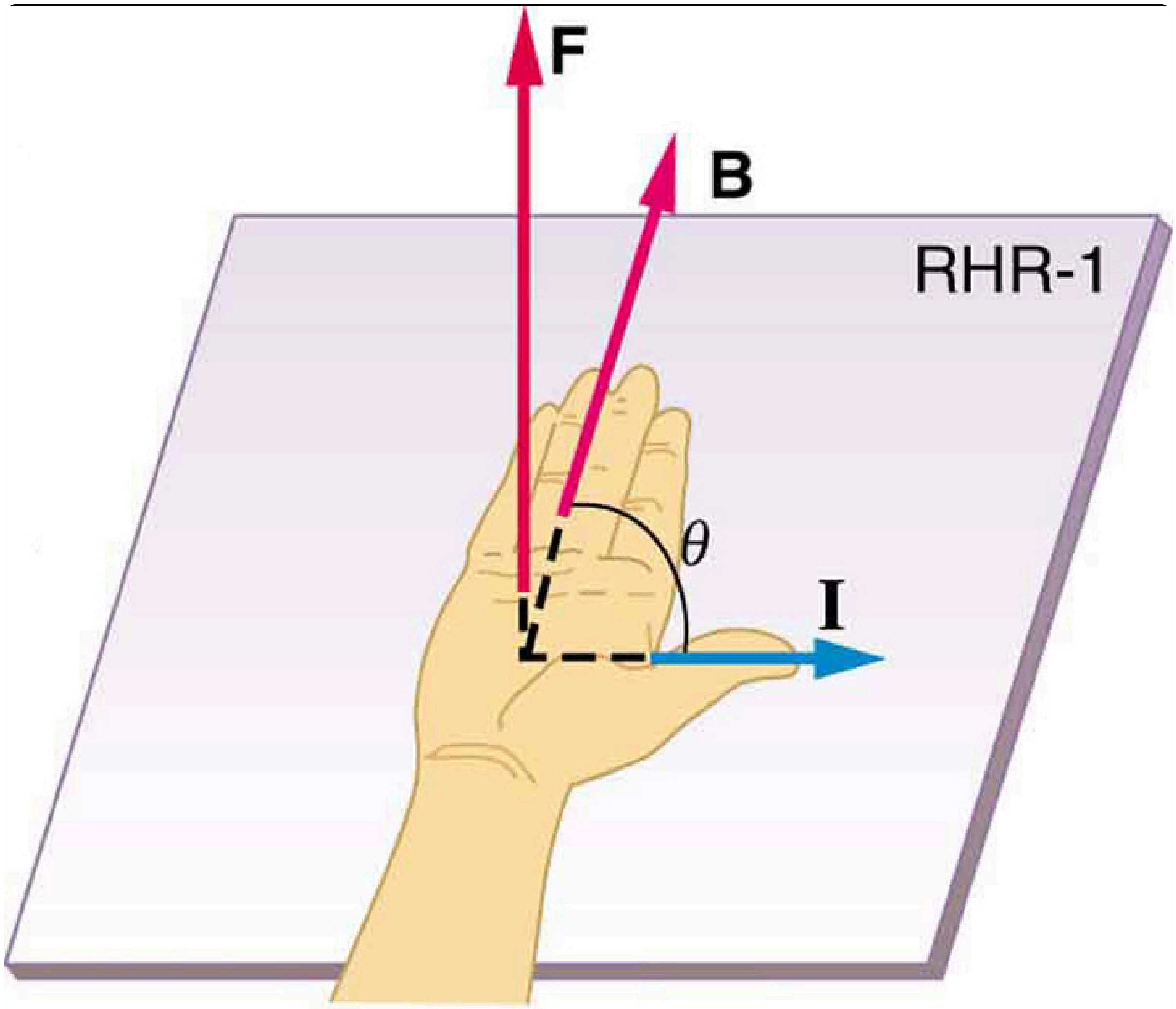
Memory Trick 🧠

"Left hand → Force → Motor."

Applying Fleming's Left-Hand Rule in a Current-Carrying Conductor

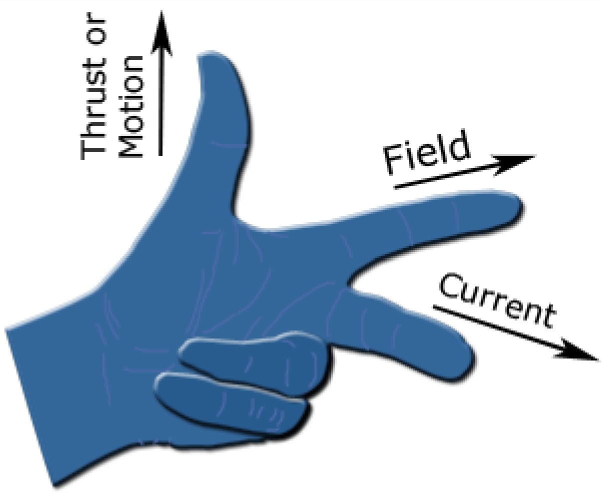
(Class 10 Physics – Magnetic Effects of Electric Current)





$$F = I\ell B \sin\theta$$

$$\mathbf{F} \perp \text{ plane of } \mathbf{I} \text{ and } \mathbf{B}$$



A. Definition (1 Mark)

Fleming's Left-Hand Rule states that:

> *If the thumb, forefinger and middle finger of the left hand are stretched mutually perpendicular to each other such that the forefinger points in the direction of the magnetic field and the middle finger points in the direction of current, then the thumb gives the direction of force (motion) acting on the conductor.*

B. Principle / Scientific Law (1–2 Marks)

> *A current-carrying conductor placed in a magnetic field experiences a mechanical force.*

- *Fleming's Left-Hand Rule is used to determine the direction of this force.*
- *This principle forms the basis of an electric motor.*

C. Conditions for Application (2 Marks)

1. *The conductor must be carrying current.*
2. *The conductor must be placed in a magnetic field.*
3. *The direction of current and magnetic field must be perpendicular to each other.*

D. Step-by-Step Application (3 Marks)

1. *Place the current-carrying conductor between the North and South poles of a magnet.*
2. *Stretch the thumb, forefinger and middle finger of the left hand mutually perpendicular.*
3. *Set:*
    - *Forefinger → Direction of magnetic field (N → S)*
    - *Middle finger → Direction of current*
    - *Thumb → Direction of force or motion*
4. *The direction shown by the thumb gives the direction of motion of the conductor.*

E. Diagram Description (For Diagram-Based Questions – 3 Marks)

- *A straight conductor placed between the poles of a magnet.*
- *Magnetic field lines shown from North to South.*
- *Direction of current indicated in the conductor.*
- *Left hand shown with:*
    - *Forefinger → magnetic field*
    - *Middle finger → current*
    - *Thumb → force / motion*

(Even if diagram is not drawn perfectly, correct labels fetch marks.)

F. Mathematical Expression (For Numericals / Concept Linking)

The magnitude of force acting on the conductor is given by:

$F=BIL$

Where:

- *F = force on the conductor*
- *B = magnetic field strength*
- *I = current*
- *L = length of conductor in the magnetic field*

(NCERT level – formula only, no derivation required.)

G. Numerical-Type Application (4 Marks)

Question: A conductor of length 0.5 m carries a current of 2 A and is placed perpendicular to a magnetic field of strength 0.4 T. Find the force acting on the conductor.

Solution:

Given:

$L=0.5m,\ I=2A,\ B=0.4T$

$F=BIL\ F=0.4\times2\times0.5=0.4N$

Answer:

The force acting on the conductor is 0.4 N.

H. Applications (Write Any One – 1 Mark)

- *To determine the direction of rotation in an electric motor.*
- *Used in DC motors, loudspeakers, and electrical measuring instruments.*

I. Limitations (2 Marks)

- *It gives only the direction, not the magnitude, of force.*
- *Not applicable when the conductor is parallel to the magnetic field.*

J. Common Board Mistakes to Avoid (Very Important ⚠️)

- ❌ *Using right hand instead of left*
- ❌ *Writing "direction of magnetic field" instead of "direction of force"*
- ❌ *Forgetting perpendicular arrangement*
- ❌ *Mixing with Fleming's Right-Hand Rule*

K. One-Line Board Answer (High-Scoring 🔑)

> *Fleming's Left-Hand Rule is applied to determine the direction of force acting on a current-carrying conductor placed in a magnetic field.*

Final Memory Trick 🧠

"Left Hand → Force → Motor."

What is a Loop?

(CBSE / ICSE Class 10 – Exam-ready)

Definition A loop is a closed conducting path (usually circular or rectangular) made of wire through which electric current can flow.

Explanation (Simple Language)

- *When current flows through a loop, it produces a magnetic field around it.*
- *A current-carrying loop behaves like a small magnet with a north and south pole.*
- *The magnetic field is strongest at the centre of a circular loop.*

One-Line Exam Answer 🔑

> *A loop is a closed conducting wire through which electric current flows.*

Quick Example

- *A single circular wire connected to a battery forms a current-carrying loop.*

Why It Is Important (1 Line)

- *Loops are the basic units of solenoids, electromagnets, and electric motors.*

If you want, I can also explain:

- *Magnetic field of a circular loop*
- *Difference between loop and solenoid*
- *Clock face rule for a loop*

A vertical wire carries current upward Using Maxwell's right hand thumb rule, state the direction of magnetic field on the right side of the wire

Answer (CBSE / ICSE Class 10 – Exam Style)

A vertical straight wire carries current upward.

Using Maxwell's Right Hand Thumb Rule:

- *Point the right thumb upward (direction of current).*
- *The curling of the fingers gives the direction of the magnetic field.*

👉 *On the right side of the wire, the magnetic field is directed into the plane of the paper (⊗).*

One-Line Board Answer 🔑

> *The magnetic field on the right side of a vertical wire carrying current upward is directed into the plane of the paper.*

Quick Memory Tip 🧠

Thumb up → Right side field goes inside (⊗), left side comes out (•).

If you want, I can also:

- *Draw a labelled diagram explanation*
- *Give a similar HOTS question*
- *Practice 2–3 more direction-based questions*

Just tell me 👍

Why does reversing the direction of current reverse the direction of magnetic field?

Why does reversing the direction of current reverse the direction of magnetic field?

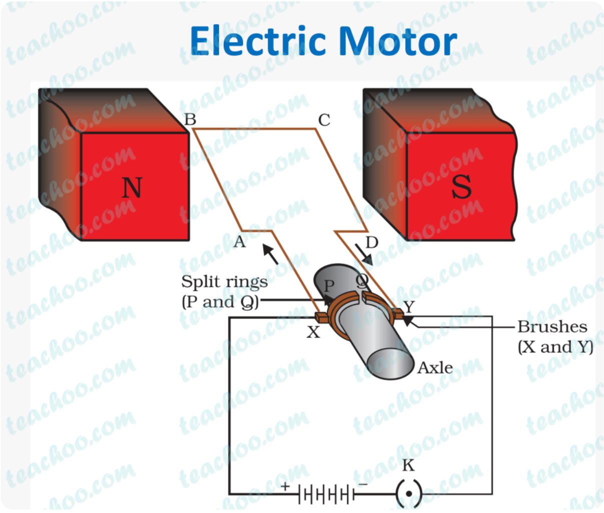
Reason / Explanation The direction of magnetic field around a conductor depends directly on the direction of current flowing through it.

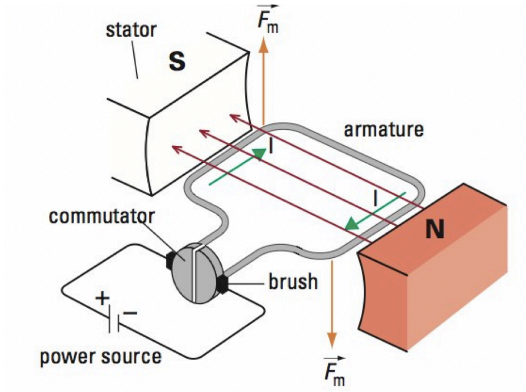
- *According to Maxwell's Right Hand Thumb Rule, the thumb shows the direction of current and the curled fingers show the direction of magnetic field.*
- *When the direction of current is reversed, the thumb points in the opposite direction.*
- *As a result, the curling of the fingers also reverses, causing the magnetic field direction to reverse.*

One-Line Board Answer 🔑

> *Reversing the direction of current reverses the direction of magnetic field because the magnetic field direction depends on the direction of current, as given by Maxwell's right hand thumb rule.*

ELECTRIC MOTOR (DC MOTOR)





1. Definition

*An **electric motor** is a device that **converts electrical energy into mechanical energy** using the **magnetic effect of electric current**.*

2. Working Principle (Very Important ⭐)

> *When a current-carrying conductor is placed in a magnetic field, it experiences a force.*

- *The direction of force is given by Fleming's Left-Hand Rule.*
- *This force causes the rotation of the coil, producing mechanical motion.*

3. Construction / Parts of an Electric Motor

(a) Insulated Copper Coil (ABCD)

- *Rectangular coil made of insulated copper wire.*
- *Placed between the poles of a magnet.*
- *Carries current and rotates due to magnetic force.*

(b) Magnet (Field Magnet)

- *Has North pole and South pole.*
- *Produces a uniform magnetic field.*

(c) Split Rings / Commutator (P and Q)

- *Two half-rings attached to the coil.*
- *Reverse the direction of current after every half rotation.*
- *Help in continuous rotation of the coil.*

(d) Axle

- *The coil and split rings are mounted on it.*
- *Helps the coil to rotate freely.*

(e) Carbon Brushes (X and Y)

- *Conducting brushes in contact with split rings.*
- *Provide current to the rotating coil.*
- *Do not rotate.*

(f) Battery / DC Source

- *Supplies electric current to the motor.*

4. Working of an Electric Motor (Step-by-Step – Exam Ready)

Initial Position

- *Current flows from battery → brush X → split ring P → coil (AB → BC → CD) → split ring Q → brush Y → battery.*

Forces on the Coil

- ***Side AB**:*

  Current flows from A to B.

  *Using **Fleming's Left-Hand Rule**, force acts **downwards**.*

- ***Side CD**:*

  Current flows from C to D.

  *Force acts **upwards**.*

Result

- *Equal and opposite forces act on the coil.*
- *The coil starts rotating in the anticlockwise direction.*

After Half Rotation

- *Split rings P and Q interchange contacts with brushes.*
- *Direction of current in the coil reverses.*

Again Applying Fleming's Left-Hand Rule

- *Forces on sides AB and CD remain in the same rotational sense.*
- *Coil continues to rotate in the same direction.*

Thus, continuous rotation is obtained due to the commutator.

5. Role of Split Ring (Commutator) – Very Important Question

Function:

- ***Reverses the direction of current in the coil after every half rotation.***
- ***Ensures that the coil continues to rotate in the same direction.***

One-Line Answer 🔑

> *The split ring acts as a commutator and reverses the current to maintain continuous rotation.*

6. Direction Rule Used

- ***Fleming's Left-Hand Rule***
  - *Forefinger → Magnetic field (N → S)*
  - *Middle finger → Current*
  - *Thumb → Force (motion)*

7. Important Facts to Remember

- ***Electric motor works on magnetic effect of current.***
- ***Direction of rotation depends on:***
  - ***Direction of current***
  - ***Direction of magnetic field***
- ***Stronger magnetic field or higher current → greater speed.***
- ***Brushes remain stationary; split rings rotate.***

8. Applications of Electric Motor

- *Electric fans*
- *Mixers and grinders*
- *Washing machines*
- *Refrigerators*
- *Water pumps*
- *Electric vehicles*

9. Advantages (Write Any One)

- *Converts electrical energy into useful mechanical work.*
- *Simple construction and efficient.*

DIRECT CURRENT (DC) AND ALTERNATING CURRENT (AC)

Alternating Current and Direct Current (AC & DC)

Alternating current and direct current are two main types of electrical current in the day-to-day world. These are two fundamental types of electrical flow. DC flows steadily in one direction, commonly found in batteries and electronics. AC changes direction periodically and is used in homes and industries for efficient power transmission. Understanding both is key to working with electrical systems. Here, we will look at both of them in great detail.

1. *Direct Current (D.C.)*

Direct current is an electric current whose direction of flow remains the same and whose magnitude may be constant or variable with time.

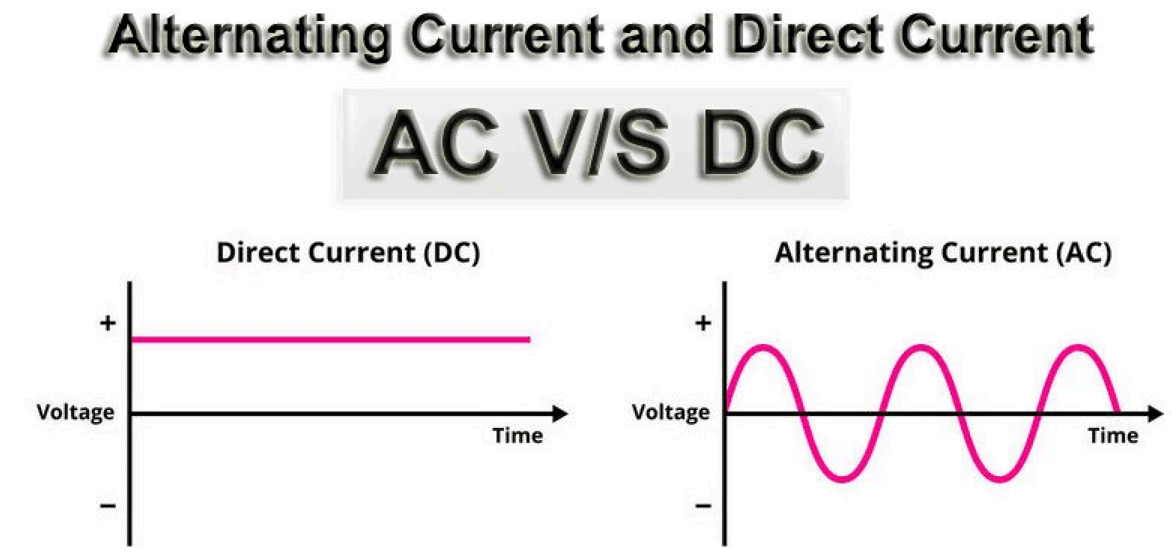
2. *Alternating Current (A.C.)*

Alternating current is an electric current whose magnitude changes continuously with time and whose direction reverses periodically.

Alternating current (AC) is where the flow of electric charge periodically reverses.

Graphical Representation (Mention in Answers)

- *DC → Straight horizontal line (constant current)*
- *AC → Sine wave alternating above and below zero*



Examples of DC

- Torch and remote control
- Mobile phone battery
- Power bank
- Car battery

Examples of AC

- *Electricity supplied to homes*
- *Ceiling fans*
- *Refrigerator*
- *Washing machine*
- *Electric iron*

Advantages of Alternating Current (AC) over Direct Current (DC)

Although both AC and DC are useful, alternating current has several advantages, especially for supplying electricity on a large scale:

Efficient transmission over long distances: AC voltage can be increased to very high values using transformers. This reduces current and minimizes power loss during transmission.

Easy change of voltage levels: The voltage of AC can be stepped up or stepped down easily with the help of transformers, making it suitable for different purposes.

Economical power distribution: AC-based power systems are cheaper to install and maintain compared to DC systems.

Well-established supply system: Most countries use AC for power supply, so the existing electrical infrastructure is designed for AC.

Lower transmission losses: When transmitted at high voltage, AC suffers less energy loss in transmission lines than DC.

One-Line Board Answer 🔑

> *AC is preferred over DC because it can be transmitted efficiently over long distances with less power loss and its voltage can be easily changed.*

Why is AC Preferred Over DC for Long-Distance Transmission? (Very Important ❓)

Reason

- AC voltage can be **stepped up to very high values** using a transformer. High voltage means **low current**. Power loss during transmission is proportional to I2R.
- Lower current → **less power loss**. Therefore, **AC can be transmitted over long distances with minimum loss**, unlike DC.

Uses of AC and DC

Uses of DC

- *Electronic circuits*
- *Charging batteries*
- *Electroplating*

Uses of AC

- *Power transmission*
- *Running household appliances*
- *Industrial machinery*

PROPERTIES OF AC

- Reversing direction: *AC periodically reverses its flow direction.*
- *Voltage variation: The voltage in AC circuits changes with time, usually in a sinusoidal form.*

- *Power transmission: Suitable for high-voltage, long-distance transmission.*
- *Transformable: Voltage levels can easily be increased or decreased using transformers*

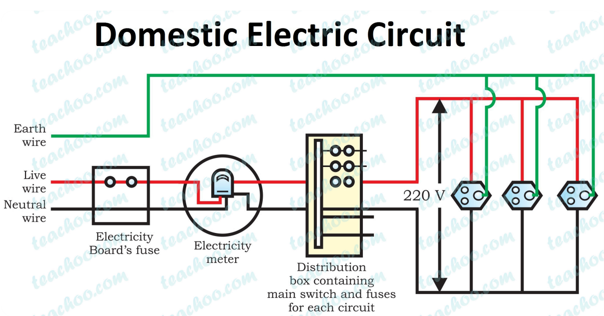
Properties of DC

- **Constant flow**: DC flows in a single, unchanging direction.
- **Stable voltage**: Provides a consistent voltage over time.
- **Battery-friendly**: Most batteries and small electronics operate on DC.
- **Efficient for low-voltage applications**: Ideal for short-distance, stable power supply systems

Differences Between AC and DC

Feature	Alternating Current (AC)	Direct Current (DC)
Flow Direction	Reverses periodically	Flows in one direction
Waveform	Sinusoidal, triangular, or square	Straight line
Frequency	50 Hz or 60 Hz (varies by region)	0 Hz (no frequency)
Standard Voltage Rating	In India, the AC has a standard Voltage Supply of 220 Volts to 240 Volts in households.	There is no standard nationwide supply voltage rating for DC in India.
Generation Source	AC generators (alternators)	Batteries, solar panels, and DC generators
Transmission	Ideal for long-distance transmission	Limited to short distances
Conversion	Easily converted to DC using rectifiers	Requires inverters to convert to AC

DOMESTIC ELECTRIC CIRCUITS



- The electric wiring system used in homes to supply electricity safely to different appliances is called a **domestic electric circuit**.
- In India, homes receive **AC supply of 220 V at 50 Hz**.

2. Working Principle (Very Important ⭐)

> **Domestic appliances are connected in parallel** so that each appliance gets the **same voltage (220 V)** and works **independently**.

- ***When the switch is ON, current flows from the live wire through the appliance and returns via the neutral wire.***
- **Earth wire** provides safety by carrying leakage current to the ground.

3. Construction / Parts of a Domestic Electric Circuit

(a) Live Wire (L)

- **Usually red/brown in colour.**
- **Carries current from the main supply to appliances.**
- **Switch and fuse are connected in the live wire.**

(b) Neutral Wire (N)

- **Usually black/blue in colour.**
- **Completes the circuit by carrying current back to the supply.**

(c) Earth Wire (E)

- **Usually green.**
- **Connected to the metal body of appliances.**
- **Prevents electric shock by safely transferring leakage current to the ground.**

(d) *Fuse*

- **A safety device made of thin wire of low melting point.**
- **Melts when excessive current flows, thus breaking the circuit.**

(e) *MCB (Miniature Circuit Breaker)*

- **Modern replacement of fuse.**
- **Automatically switches OFF during overload or short circuit.**
- **Can be reset easily.**

(f) Main Switch

- **Controls the entire house supply.**
- **Used to cut off power during repair or emergency.**

(g) Electric Meter

- Measures electrical energy consumed in kilowatt-hour (kWh).

Q. Why Appliances Are Connected in Parallel? (Board Favourite ❓)

1. Each appliance gets full voltage (220 V).
2. Appliances work independently.
3. Switching OFF one appliance does not affect others.

Important Facts to Remember (Exam Points ⭐)

IMPORTANT

Supply voltage in homes: 220 V AC, 50 Hz

Appliances are connected in parallel

Fuse/MCB always in live wire

Earth wire prevents electric shock

Thick wires are used to avoid overheating

Electric energy unit: kWh

Q. Why is fuse connected in the live wire?

So that when it melts, it cuts off the live supply, making the appliance safe.

Q. Why is earth wire thicker?

To provide a low-resistance path for leakage current.

Advantages of Proper Domestic Wiring

- *Safe use of electricity*
- *Protection from fire and shock*
- *Efficient operation of appliances*

One-Page Revision Summary 🔁

- *Domestic circuit → parallel connection*
- *Supply → 220 V AC*
- *Safety → Fuse / MCB + Earth wire*
- *Live wire → switch & fuse*
- *Meter → measures energy*

TUTOR: DEV ARGHYA ROY

CHAPTER : MAGNETIC EFFECTS OF ELECTRIC CURRENT