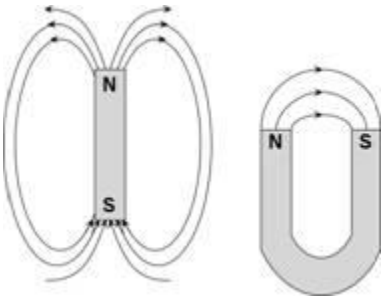
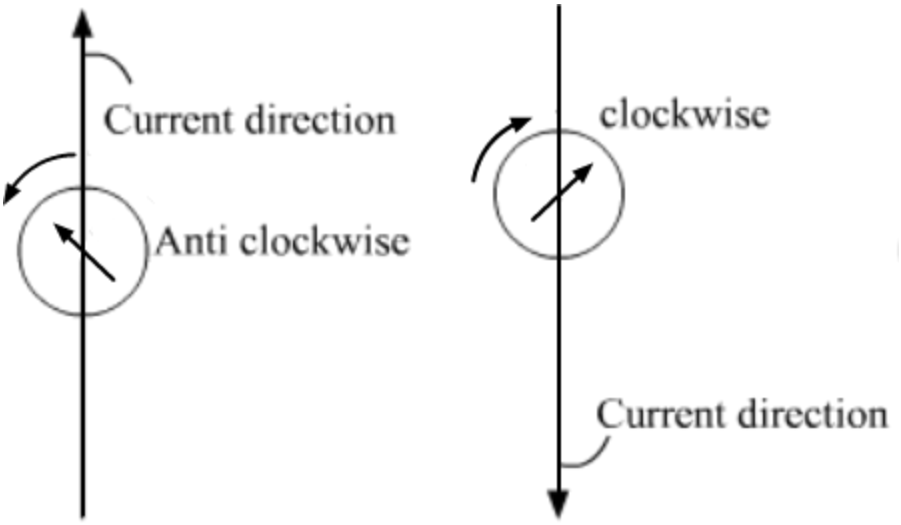
Magnetic Effects of Electric Current

- **Properties of Magnetic field lines**
  - Originate from the North pole and end at the South pole [outside the magnet]
  - They are closed continuous lines
  - Density of the lines increases near the poles and decreases away from the poles
  - Lines never cross each other

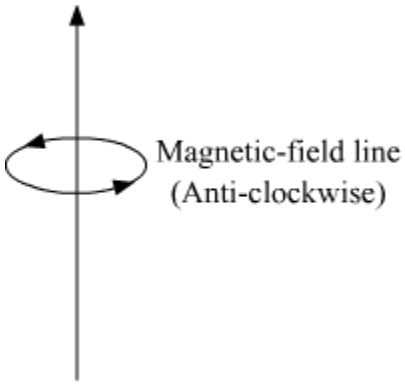


- Like poles repel and unlike poles attract each other.
- The region where magnetic field lines are crowded has relatively greater strength
- The magnetic poles of the Earth continuously change their position with time i.e., the magnetic North Pole becomes the magnetic South Pole and vice-versa. This phenomenon of flipping of poles is known as **magnetic reversal**.
- The angle of the horizontal plane between the geographic North (true North) and the magnetic North is known as **magnetic declination**.

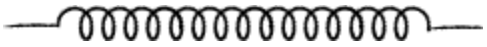
- **Deflection of compass**



- **Right-hand thumb rule**



- **Solenoid**
  - A cylindrical coil having many turns of insulated wires wrapped closely



- **Right-hand thumb rule/ Maxwell's corkscrew rule**
  - If one holds a current-currying wire in the right hand such that the thumb is pointing in the direction of the current, then the direction in which the other finger encircles the wire will give the direction of the produced magnetic field lines around the wire.
- **Corkscrew rule**
  - **If one drives a corkscrew in the direction of the current, then the direction in which the handle is turned is the direction of the magnetic field on the magnetic field lines.**
- **The magnitude of the field lines produced by a circular loop at its centre is**
  - directly proportional to the amount of current
    inversely proportional to the radius of the loop
- The strength of the magnetic field produced by a current carrying a solenoid

  1. is directly proportional to the number of turns in the solenoid
  2. is directly proportional to the strength of the current in the solenoid
  3. depends upon the nature of the core material

- A current carrying the rod experiences a force when placed between two poles of strong magnets. The direction of force exerted on the rod is related with the direction of current.
- Magnitude of magnetic force depends upon three factors:

  (1) $F \propto I$ (current I flowing in the rod)(2) $F \propto B$ (Strength of magnetic field B)(3) $F \propto l$ (length of the rod l)

  where *K* is a constant and its value in SI unit is 1.
  So, $F = IBl$
  Fleming's left-hand rule
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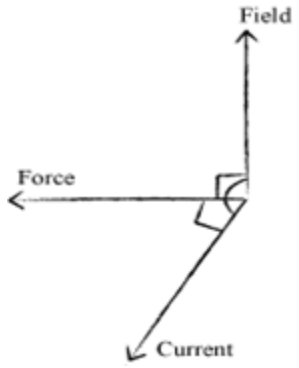
  - If the thumb, forefinger, and middle finger of the left hand are stretched in such a way that they are mutually perpendicular to each other and the forefinger points in the direction of

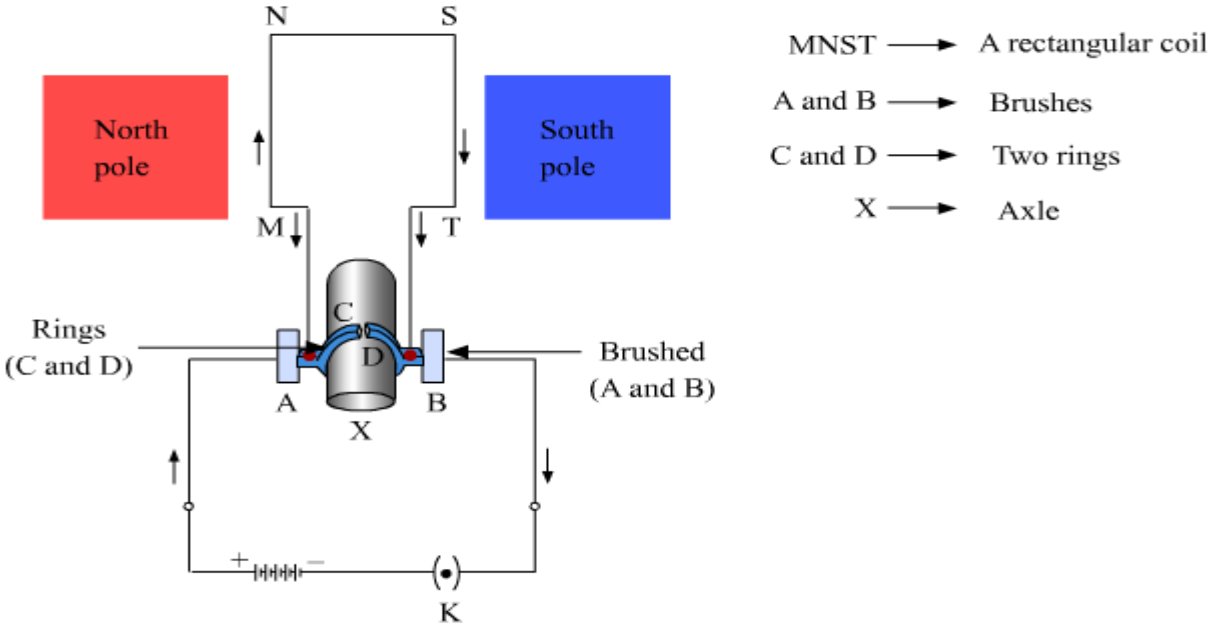
the magnetic field and the middle finger in the direction of the current, then the thumb will point in the direction of the force acting on the conductor.

Fore finger = Magnetic field
Middle finger = Current
Thumb = Force on conductor



- **<u>Application</u>** – Electric motor

- An electric motor is a rotating device that converts electrical energy into mechanical energy.
- **Motor principle:** The basic principle on which the electric motor works is the magnetic effect of current. A current carrying rectangular coil starts rotating when placed in a magnetic field.
- **Simple electric motor**



- An electric device that reverses the direction of current in a circuit is called a **commutator**. The split ring acts as a commutator of the electric motor.

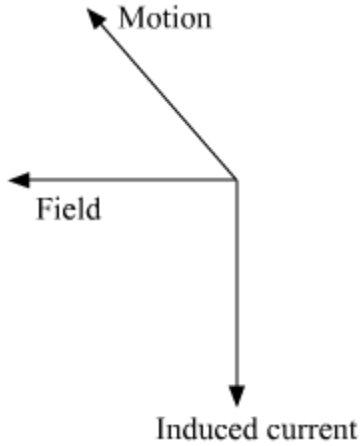
- The phenomenon of the generation of induced current in a conductor by changing the magnetic field or by moving a conductor in the magnetic field is known as **electromagnetic induction.**
  e(induced e.m.f.)=change in magnetic flux in each turn×number of turn in the coiltime in w hich the magnetic flux changes

  The direction of induced e.m.f is given by Lenz's law according to which the direction of induced e.m.f. (or induced current) is such that it opposes the cause which produces it.

  Difference between A.C. and D.C.

Direct Current (D.C.)	Alternating Current (A.C.)
Current of constant magnitude	Magnitude of current varies periodically with time
Always flow in one direction	Direction of current reverses periodically
Can be obtained from cell or battery	Can be obtained from A.C. generator

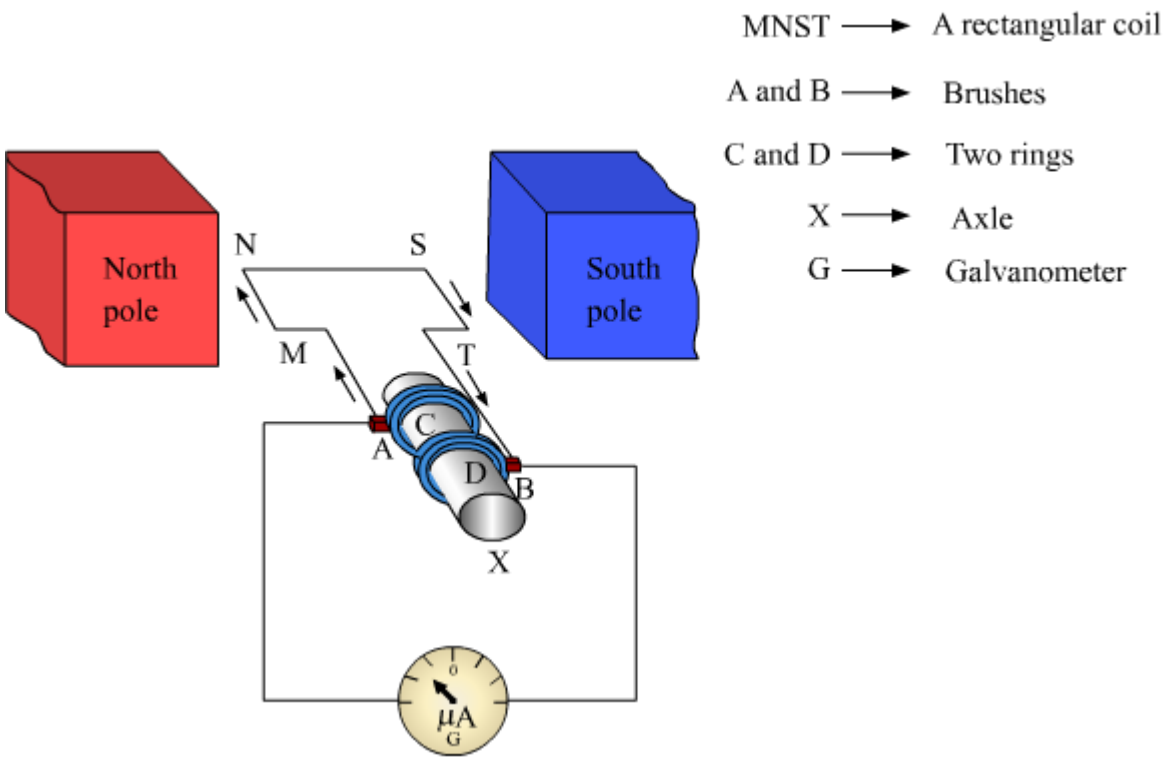
- The working of a transformer is based on the phenomenon of mutual induction.
- The direction of the current induced with respect to the directions of the magnetic field and motion of the coil is given by **Fleming's right hand rule**.
  - If the thumb, forefinger, and middle finger of the right hand are stretched in such a way that they are mutually perpendicular to each other and the forefinger points in the direction of the magnetic field and the thumb points towards the motion of the conductor, then the middle finger will point in the direction of the current through the conductor.
    Fore finger = magnetic field
    Thumb = movement of conductor
    Middle finger = direction of current



- **Application** – Generator

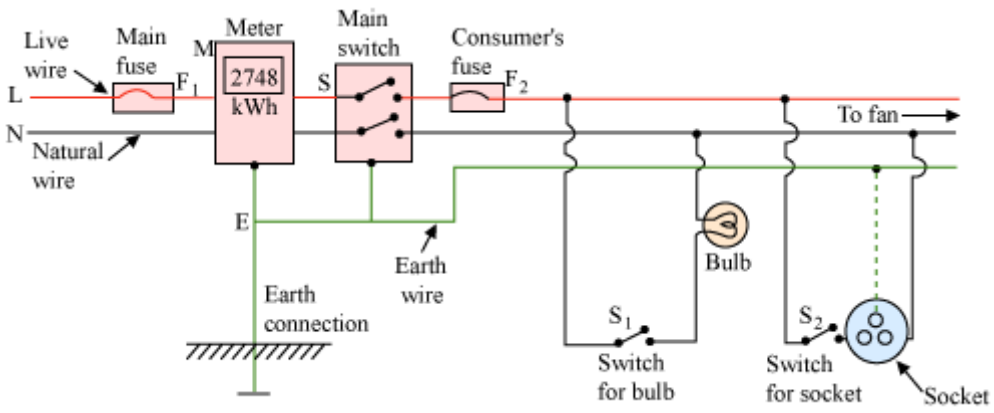
- **Electric Generator** converts mechanical energy into electrical energy.

- The direction of the induced current in the generator is given by **Fleming's right hand rule**.
- **Simple electric generator:**



- To get a current that flows in one direction only, a split ring is used.
- Most power stations in the world generate AC than DC. This is because AC can be transmitted over very long distances without much loss of energy.

- **Domestic wiring**
  Electricity is transferred to our homes through a pair of wires consists of a red colour wire (called **live wire, L),** and a black colour wire (called **neutral wire, N).** In addition to these wires, a green colour wire known as the **Earth wire, E** is also connected with the circuit. In India, 220 V potential is supplied through live wire, while neutral wire has ground potential of zero volts.



- **Switches**: It is a device which is connected in the live wire so as to turn 'ON' or 'OFF' the current in the circuit.

  Types of switches:
  1) Single pole switch:
  2) Double pole switch:
- Fuse is the most important safety device, used for protecting the circuit due to short-circuiting or overloading of the circuit.

  Characteristic of electric fuse

- Fuse wire has low melting point. It is generally made up of an alloy of lead and tin.
- Fuse wire is always connected in the series with the live wire. Its resistance is higher than that of the copper wires. So it gets heated up much faster than the copper wire when excessive current flows through it.
- Current rating of the fuse wire decides its thickness. More the current rating of the fuse wire, more will be its thickness.