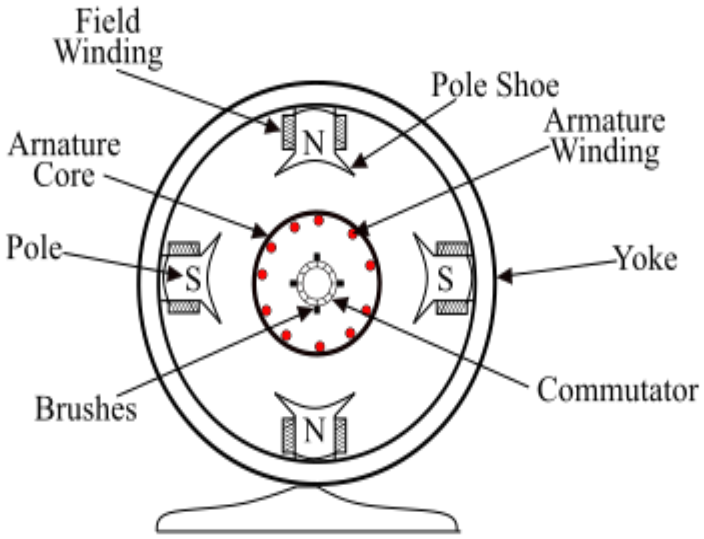
DC MOTOR

A direct current motor (DC motor) is defined as an electrical machine that converts electrical energy into mechanical energy. Based on the definition above, we can conclude that a DC motor is defined as an electric motor that operates on direct current. A DC motor is an electric motor that runs on direct current (DC), unlike an induction motor that operates via an alternating current.

It operates on the Lorentz principle, which states that "a current-carrying conducter placed in a magnetic and electric field experiences a force." That force is known as the Lorentz force . Fleming's Left-hand Rule determines the direction of the mechanical force.

Construction of a DC Motor



A DC motor consists of six main parts, which are as follows

Yoke

The outer frame of a DC motor is a hollow cylinder made up of cast steel or rolled steel is known as yoke. The yoke serves following two purposes

- It supports the field pole core and acts as a protecting cover to the machine.
- It provides a path for the magnetic flux produced by the field winding.

Magnetic Field System

The magnetic field system of a DC motor is the stationary part of the machine. It produces the main magnetic flux in the motor. It consists of an even number of pole cores bolted to the yoke and field winding wound around the pole core. The field system of DC motor has salient poles i.e. the poles project inwards and each pole core has a pole shoe having a curved surface. The pole shoe serves two purposes

- It provides support to the field coils.
- It reduces the reluctance of magnetic circuit by increasing the cross-sectional area of it.

The pole cores are made of thin laminations of sheet steel which are insulated from each other to reduce the eddy current loss. The field coils are connected in series with one another such that when the current flows through the coils, alternate north and south poles are produced.

Armature Core

The armature core of DC motor is mounted on the shaft and rotates between the field poles. It has slots on its outer surface and the armature conductors are put in these slots. The armature core is a made up of soft steel laminations which are insulated from each other and tightly clamped together. In small machines, the

laminations are keyed directly to the shaft, whereas in large machines, they are mounted on a spider. The laminated armature core is used to reduce the eddy current loss.

Armature Winding

The insulated conductors are put into the slots of the armature core. The conductors are suitably connected. This connected arrangement of conductors is known as armature winding. There are two types of armature windings are used – wave winding and lap winding.

Commutator

A commutator is a mechanical rectifier which converts the direct current input to the motor from the DC source into alternating current in the armature winding. The commutator is made of wedge-shaped copper segments insulated from each other and from the shaft by mica sheets. Each segment of commutator is connected to the ends of the armature coils.

Brushes

The brushes are mounted on the commutator and are used to inject the current from the DC source into the armature windings. The brushes are made of carbon and is supported by a metal box called brush holder. The pressure exerted by the brushes on the commutator is adjusted and maintained at constant value by means of springs. The current flows from the external DC source to the armature winding through the carbon brushes and commutator.

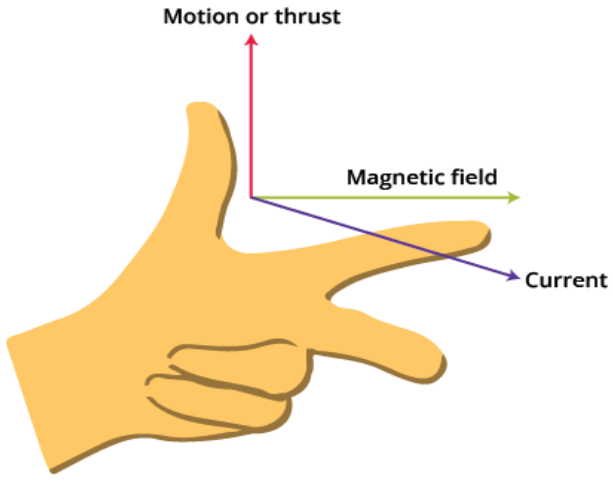
Working principle or Principle of Operation for DC Motor

The operation of a direct current (DC) motor is based on the principle that when a current-carrying conductor is placed in a magnetic field, the conductor experiences a mechanical force. The direction of force is given by Fleming's left-hand rule and the magnitude of this force is given by:

$$F = BIL \text{ Newtons}$$

Where B is a magnetic field, I is current and L is the length of the conductor.

According to Fleming's Left Hand Rule, if we arrange our thumb, forefinger and middle finger of the left-hand perpendicular to each other, the thumb will point in the direction of the magnetic force, the forefinger will point in the direction of the magnetic field and the middle finger will point in the direction of the current.

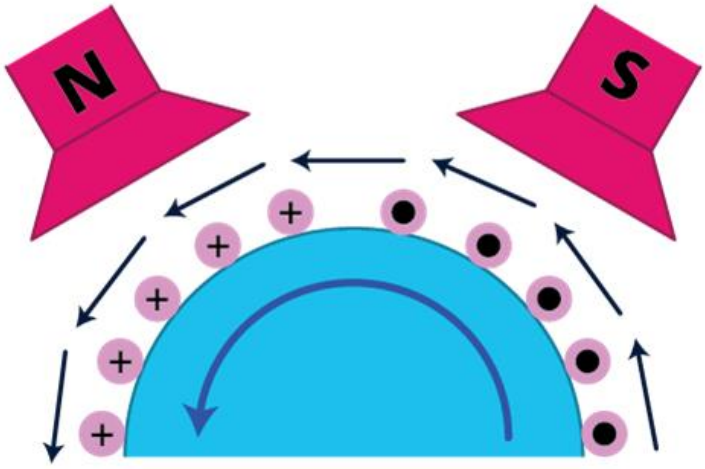


Fleming's Left-Hand Rule

Basic Motor Operation Function

The field magnets are excited, resulting in the formation of alternate North and South poles.

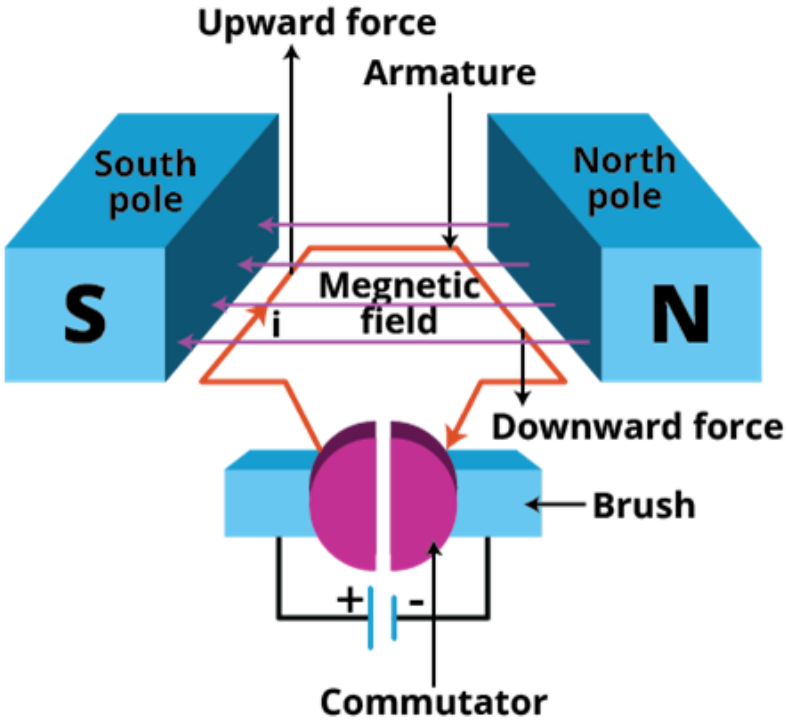
Currents are carried by armature conductors.



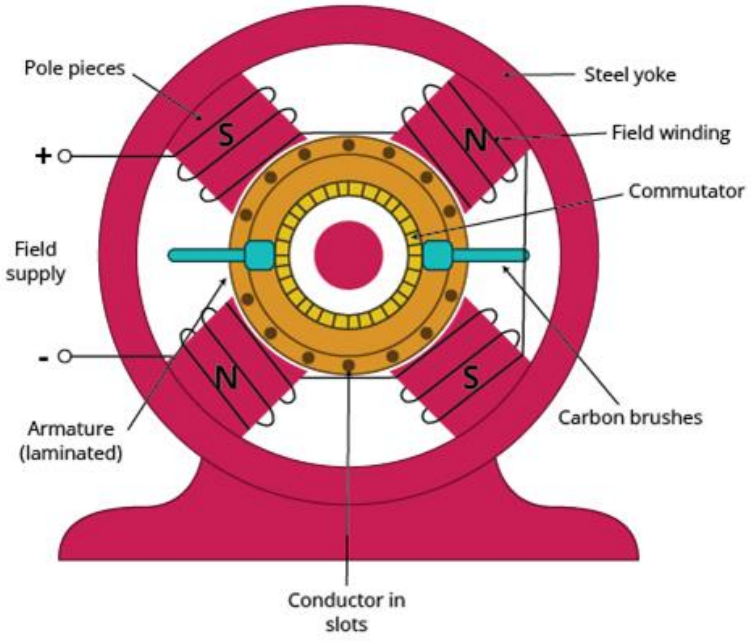
Poles and part of DC motor

All North-pole conductors carry currents in one direction, while all South-pole conductors carry currents in the opposite direction. Currents are carried into the plane of the paper by the armature conductors under the N-pole (denoted as in the figure). The conductors beneath the S-pole carry currents away from the plane of the paper (shown in the figure).

A mechanical force acts on each armature conductor because it is carrying current and is placed in the magnetic field. Using Fleming's left-hand rule, it is clear that the force on each conductor tends to rotate the armature anticlockwise. All of these forces combine to create a driving torque that sets the armature to rotate.



Simple DC motor



Cross-section of DC motor

The current in a conductor is reversed when it moves from one side of a brush to the other. At the same time, it is influenced by the next pole, which has the opposite polarity. As a result, the direction of the force on the conductor remains constant. It should be noted that the function of a commutator in a motor is the same as that of a commutator in a generator. It helps to develop a continuous and uni-directional torque by reversing the current in each conductor as it passes from one pole to another.

DC Motor E.M.F Equation

As the armature conductors are carrying currents and the armature rotates inside the stator magnetic field, it also produces an emf E_b in a manner very similar to that of a generator.
The generated Emf E_b is directed opposite to the supplied voltage and is known as the back Emf, as it counters the forward voltage.
The back emf like in case of a generator is represented by

$$E_b = \frac{P.\varphi.Z.N}{60.A} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where, P = no of poles
φ = flux per pole
Z= No. of conductors
A = No. of parallel paths
and N is the speed of the DC Motor.

Application of DC Motor

A direct current motor is a type of motor in which we use a permanent magnet to generate the necessary magnetic field. As this motor does not need to control the speed, it is used in applications like:

- Washer
- Automobiles as a starter motor
- Personal computer disc drives
- Toys, Wheelchairs, Blowers in heater and air conditioners