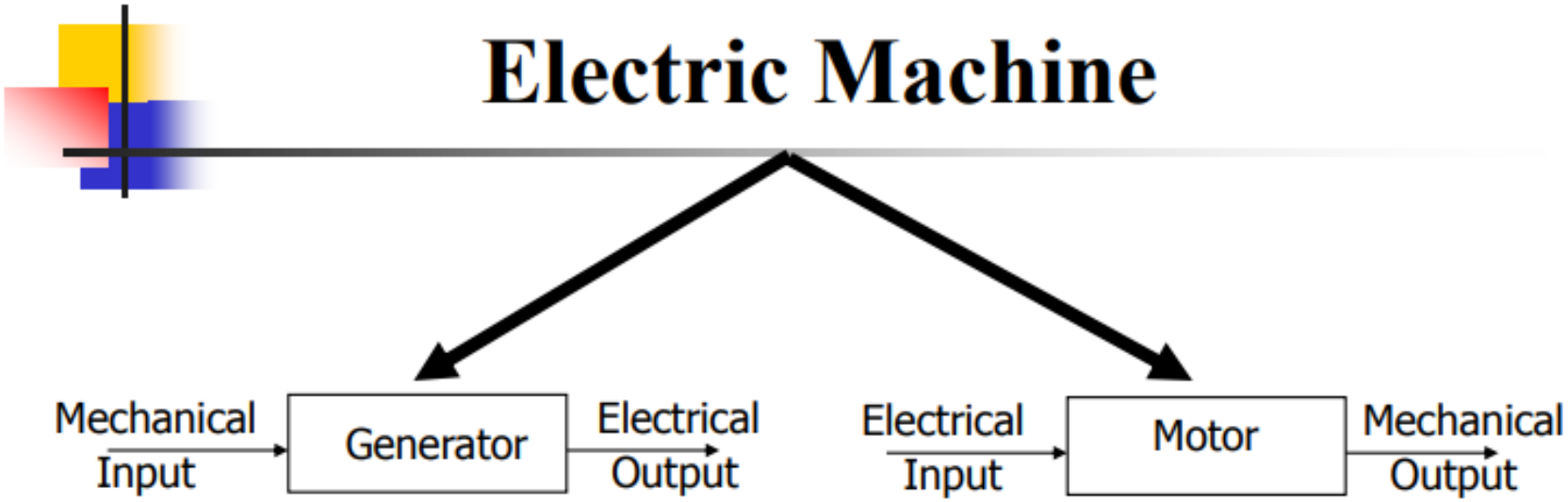
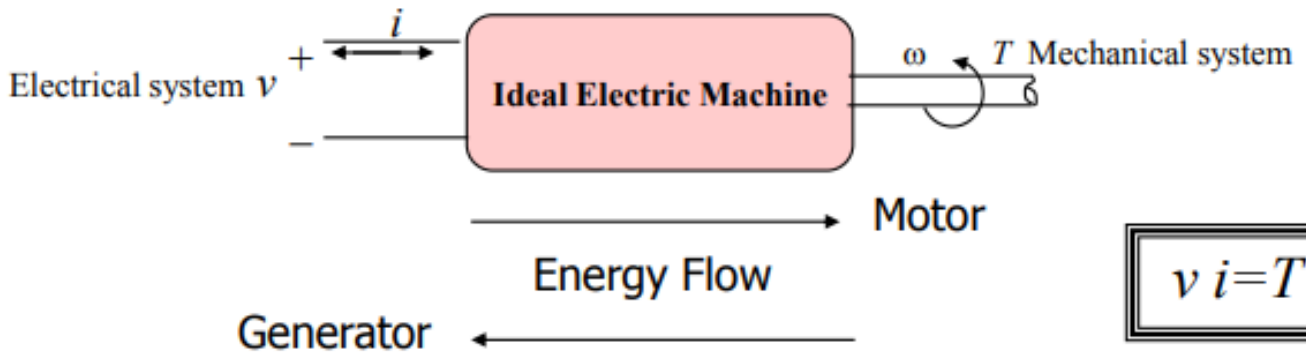
UNIT-3-Motors

Prepared By Pawandeep Kaur

DC Machine



Electromechanical Energy Conversion



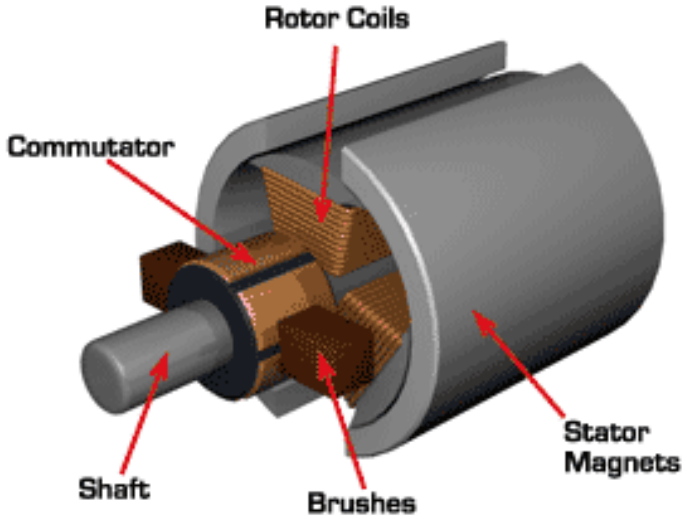
$$v\,i = T\,\omega$$

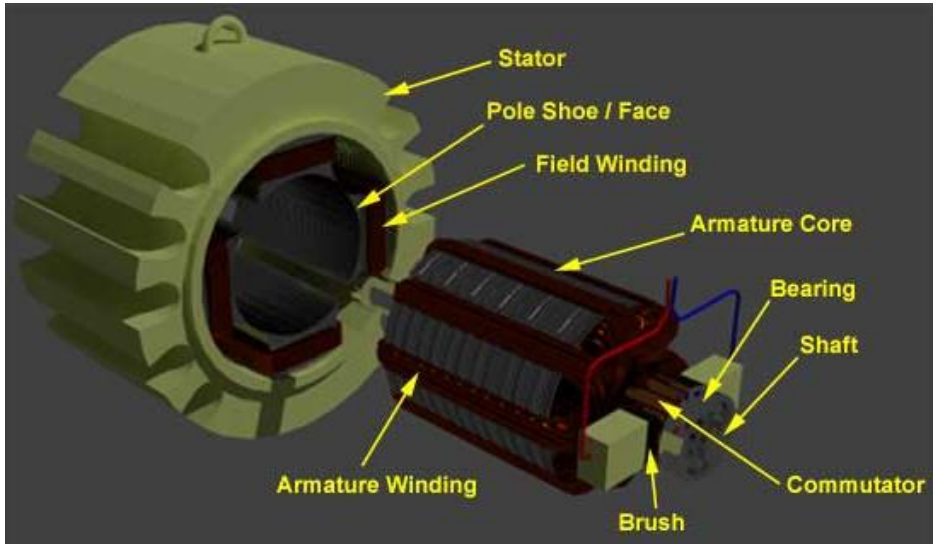
Construction of a DC Machine

DC machine has mainly two parts;

- ❑Stator, and
- ❑Rotor

- The stator is the outer frame of the machine and is immovable.
- The rotor is free to move and is the inner part of the machine.





Explanation

Parts of the Stator

1. **Yoke:**

- The magnetic frame or the **yoke** is made up of **cast iron or steel** and forms an integral part of the stator or the static part of the motor.
- Its main function is to form a protective covering over the sophisticated inner parts of the motor and provide support to the armature. It also supports the field system by housing the magnetic poles and field winding of the DC motor.

Parts of the Stator

2. **Poles:**

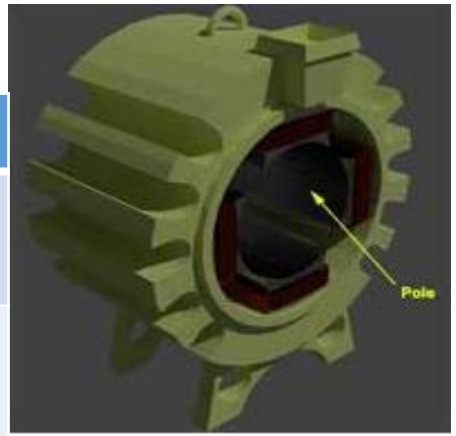
The magnetic poles of DC machine are structures fitted onto the inner wall of the yoke with screws.

The construction of magnetic poles basically comprises of two parts. Namely,

the **pole core and the pole shoe**.

These two structures are assigned for different purposes:

Pole Core	Pole Shoe
Solid piece made up of solid cast iron or cast steel	It is an extended part of pole core
	Spreads out the flux in the gap Reduces the reluctance
May be laminated	Laminated



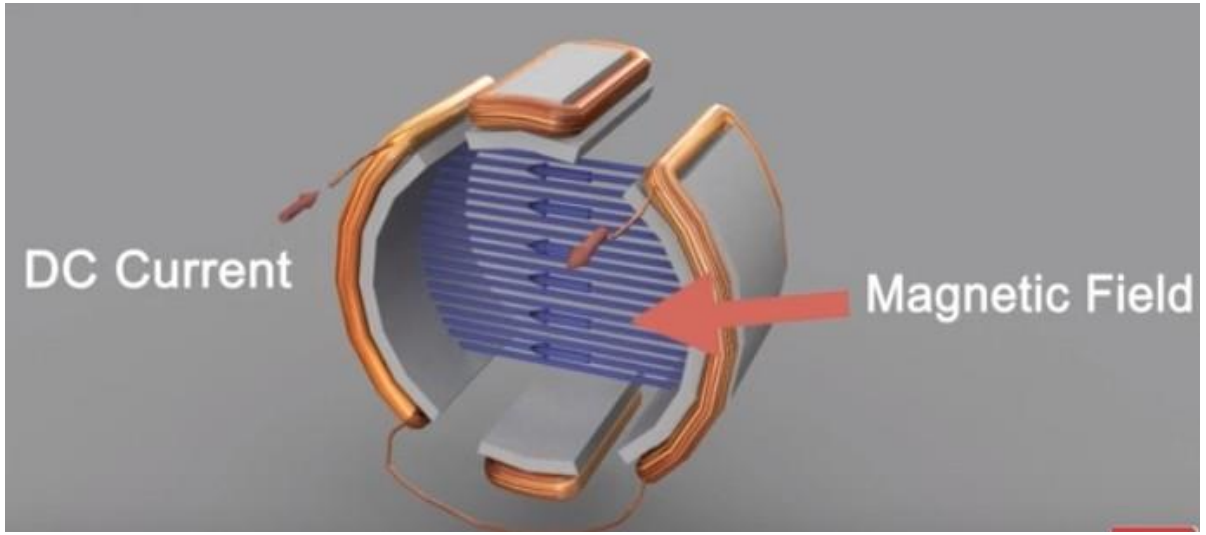
Construction of a DC Machine

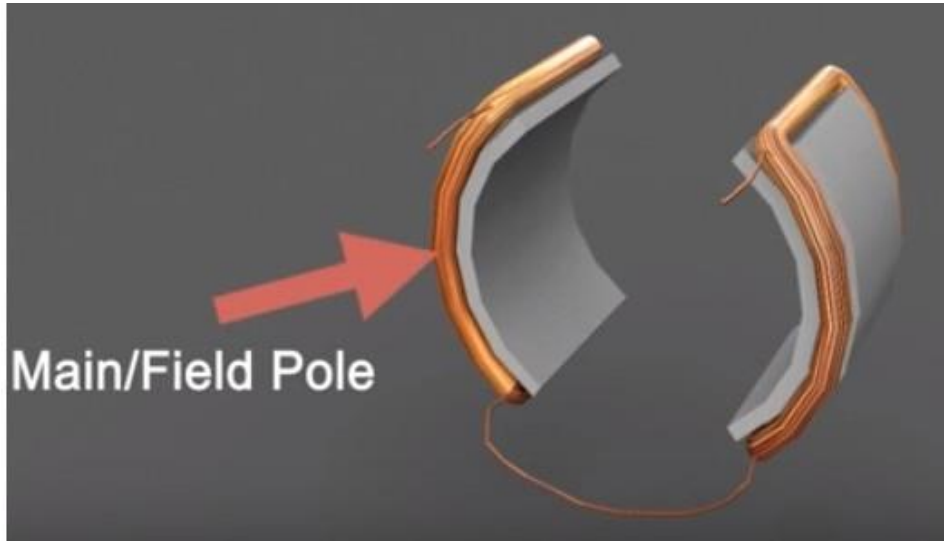
- When DC current is pass through the windings it creates a static magnetic field.

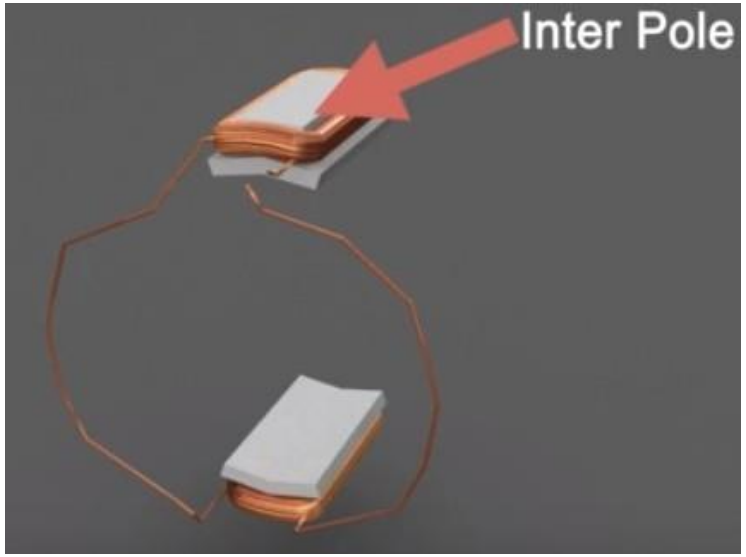
- There are two types of pole in a DC machine.

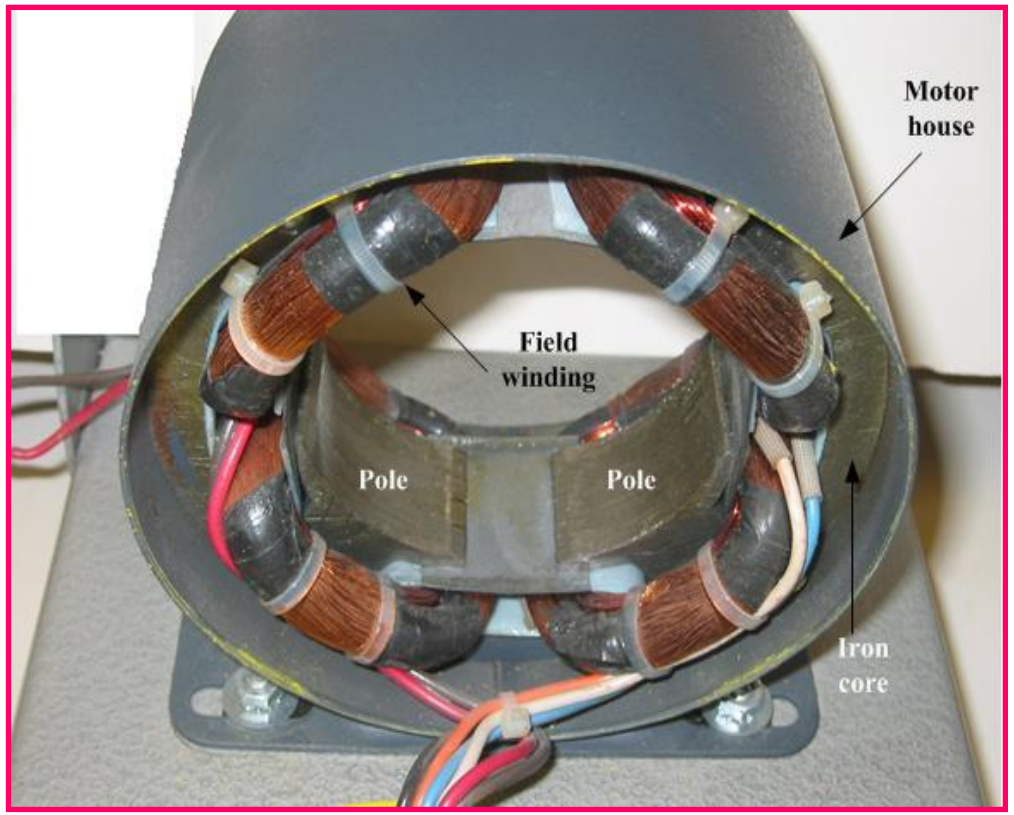
1. Pole core (Field Pole)

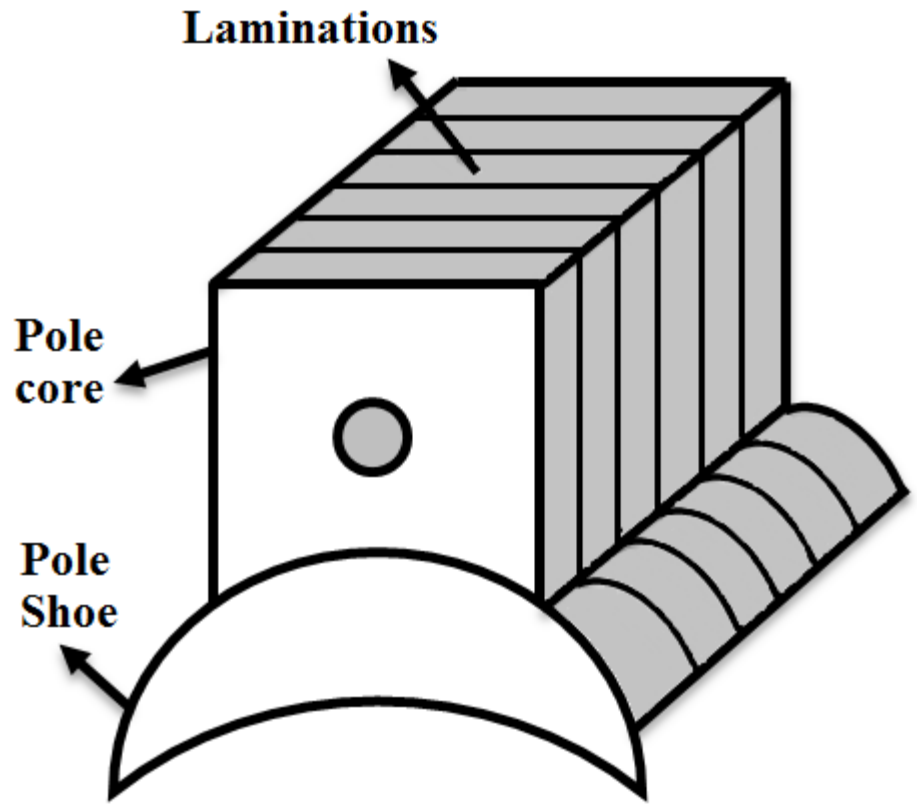
2. Pole Shoe







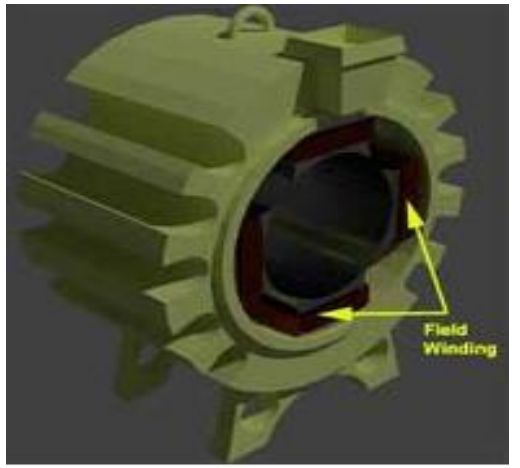

Motor
house
Field
winding
Pole
Pole
Iron
core


Laminations
Pole
core
Pole
Shoe

Parts of the Stator

3. **Field Winding:**

The field winding of DC machine are made with field coils (copper wire) wound over the slots of the pole shoes in such a manner that when field current flows through it, then adjacent poles have opposite polarity are produced. The field winding basically form an electromagnet, that produces field flux within which the rotor armature of the DC motor rotates, and results in the effective flux cutting.



QUICK QUIZ (POLL)

Which of the following is **NOT** the part of the stator?

a) Yoke

b) Pole Shoe

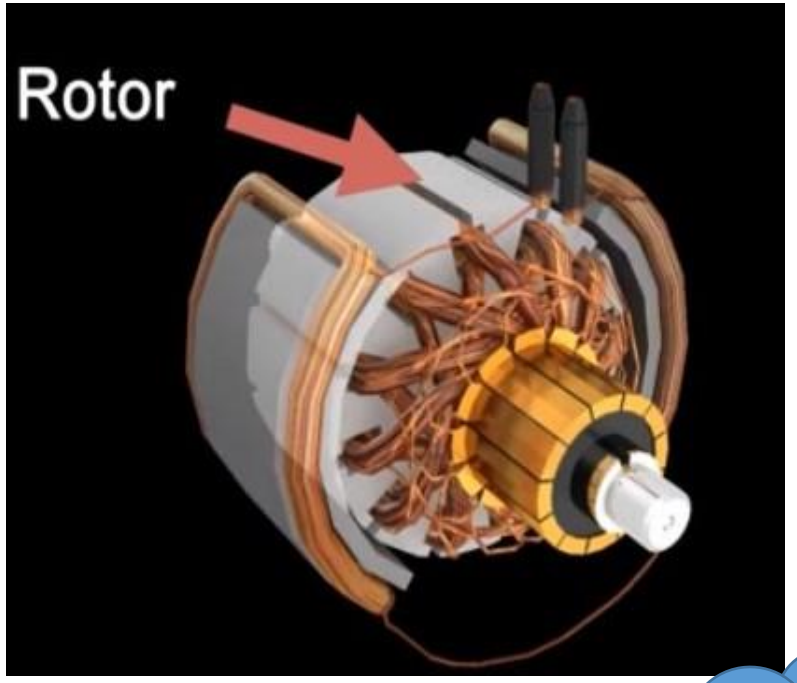
c) Field Windings

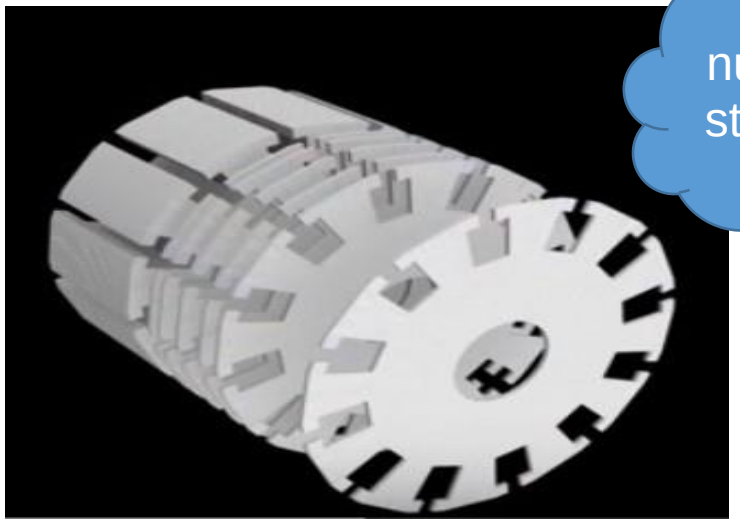
d) Armature Windings

Parts of the Rotor

1. Armature:

- Armature core is a cylindrical drum mounted on the shaft.
- It is provided with large number of slots all over its periphery and it is parallel to the shaft axis.
- Armature conductors are placed in these slots. Low reluctance, high permeability material such as silicon steel is used for armature core.
- Armature winding is supposed to carry the entire load current hence it should be made up of conducting material such as copper.
- Laminated: Reduce Eddy current Losses
- Steel: To reduce hysteresis losses
- The air holes: are also provided on the armature core for the air circulation which helps in cooling the motor.





number of stampings

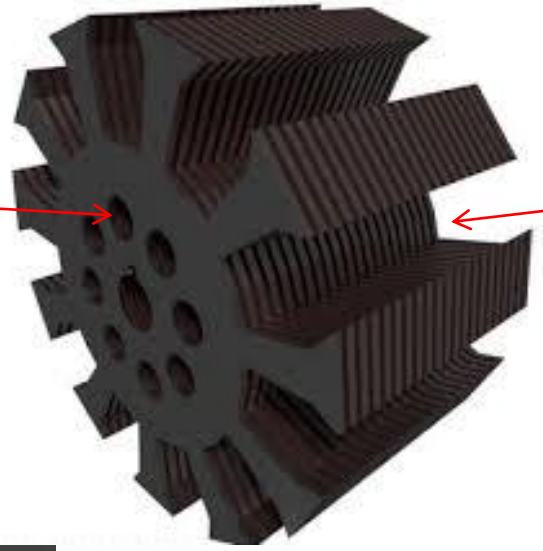
POLL -1:

Air holes are used:

A)To Reduce Eddy current Losses

B)To reduce hysteresis losses

C)for the air circulation which helps in cooling the motor.



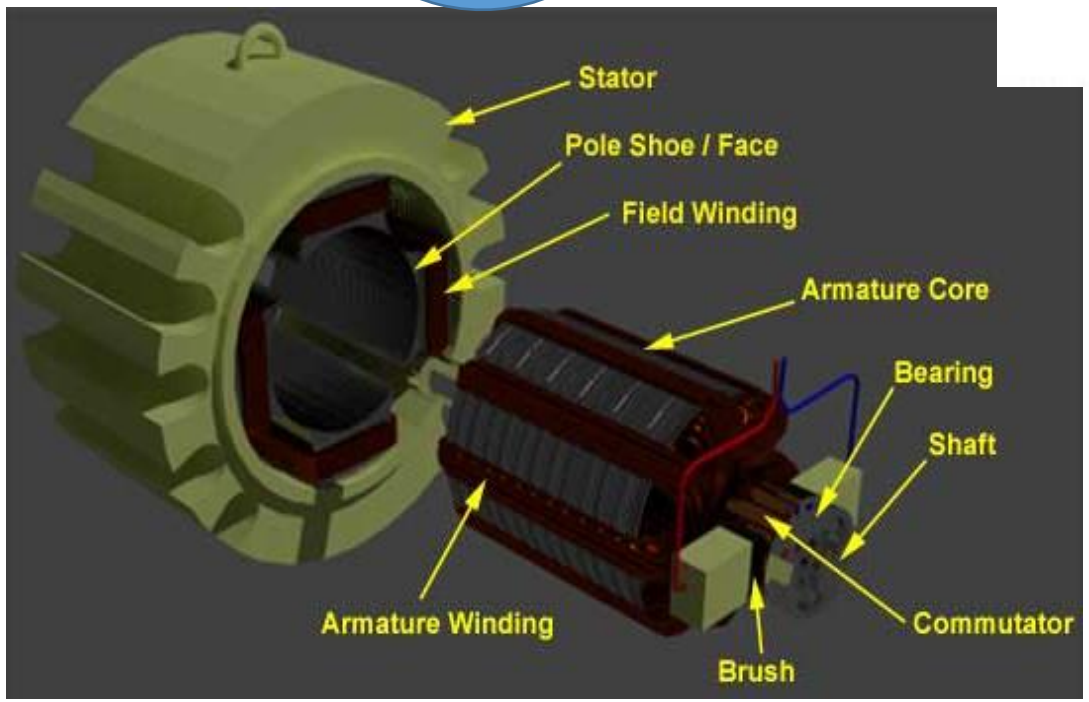
POLL-2:

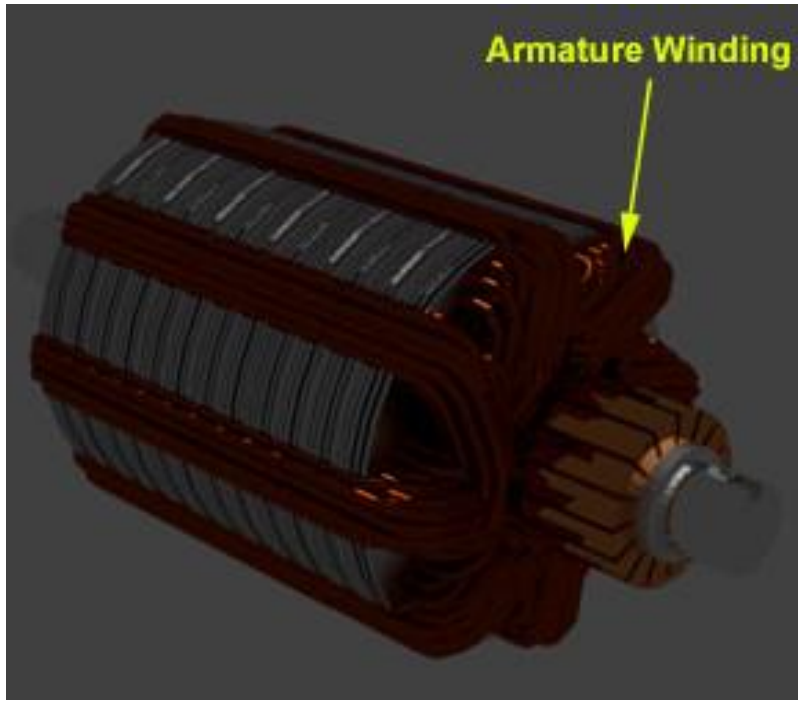
The image in figure represents

A) Slot (Core)

B) Armature winding

C) stamp

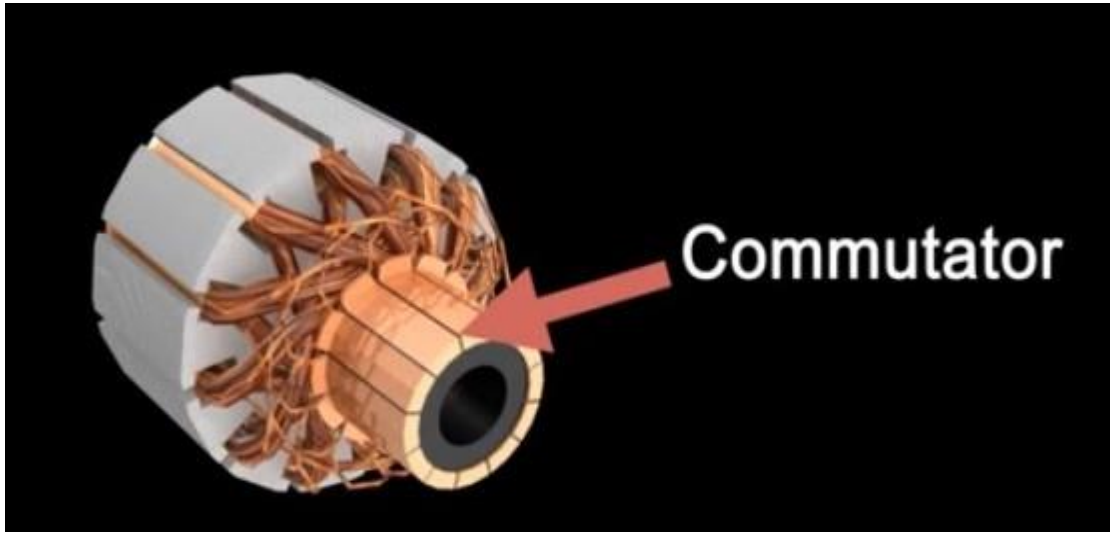




Construction

- Slots are cut on the outer periphery of rotor or we can say “armature”, which receive coils/windings made up of copper conductor.

- Each coil gets connected to an external DC source by a pair of commutator segments arranged in the form of a Ring.



Parts of the Rotor

2. **Commutator:**

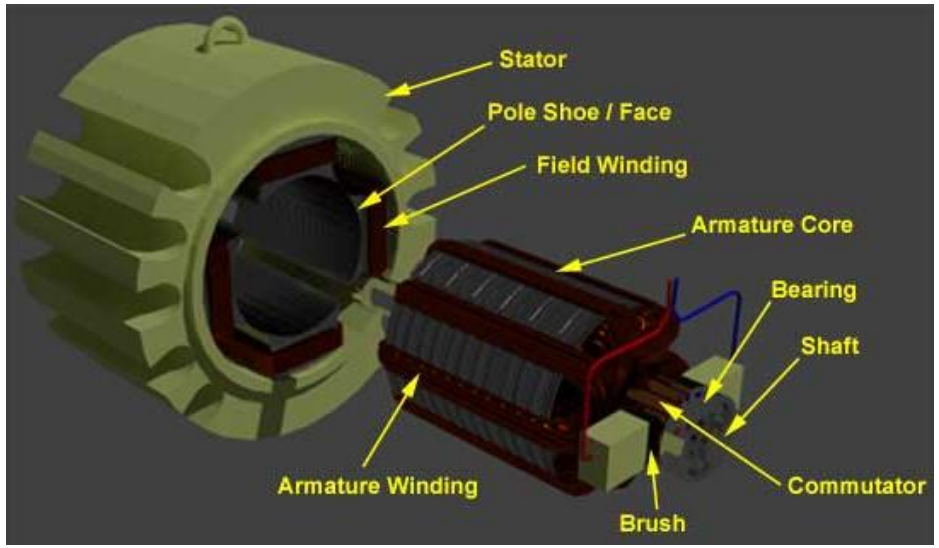
The commutator of DC motor is a cylindrical structure made up of copper segments stacked together, but insulated from each other by mica.

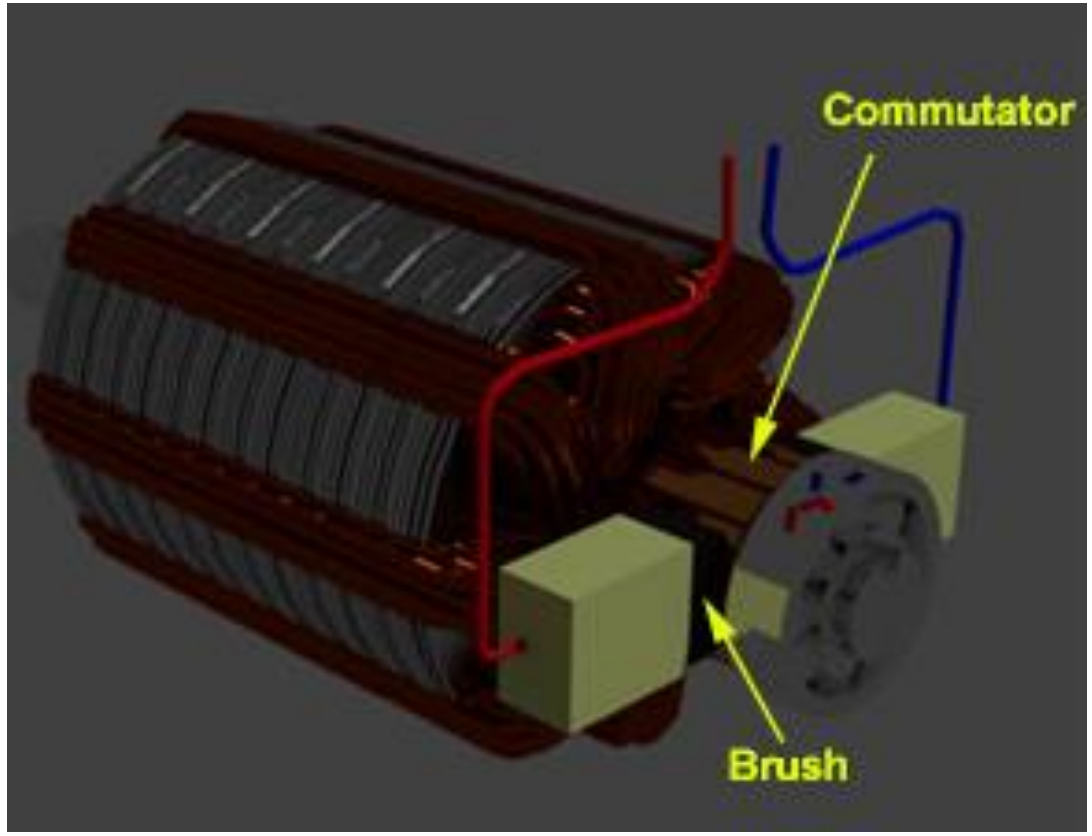
- It converts the ac emf generated internally into dc
- It helps to produce unidirectional torque.
- **Material Used:** it is made up of **copper** and insulating material between the segments is **mica**.

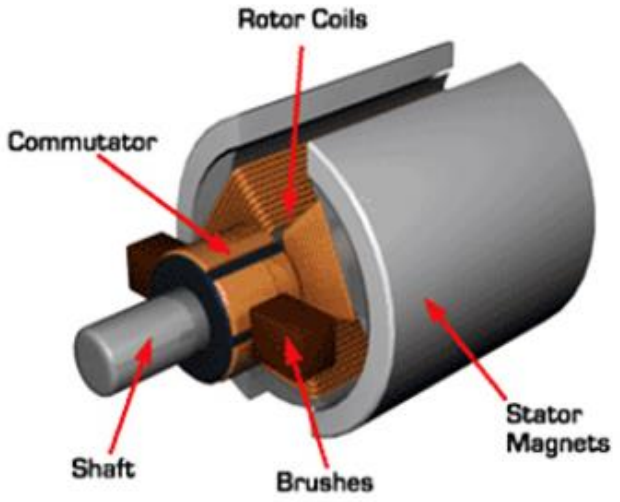
Parts of the Rotor

3. **Brushes**

- The brushes of DC motor are made with **carbon or graphite** structures, making sliding contact over the rotating commutator.
- The brushes are used to relay the current from external circuit to the rotating commutator form where it flows into the armature winding.



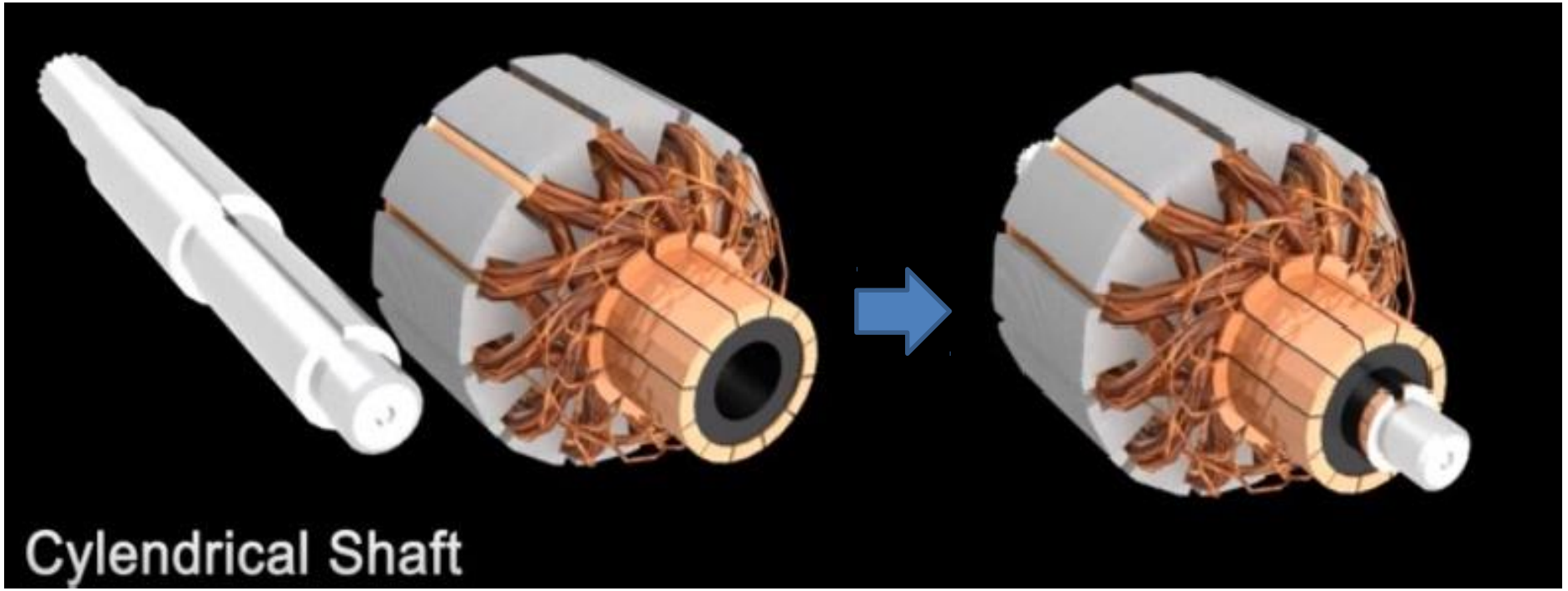

Commutator
Brush


Rotor Coils
Commutator
Shaft
Brushes
Stator
Magnets

Miscellaneous parts Construction

1.Shaft:

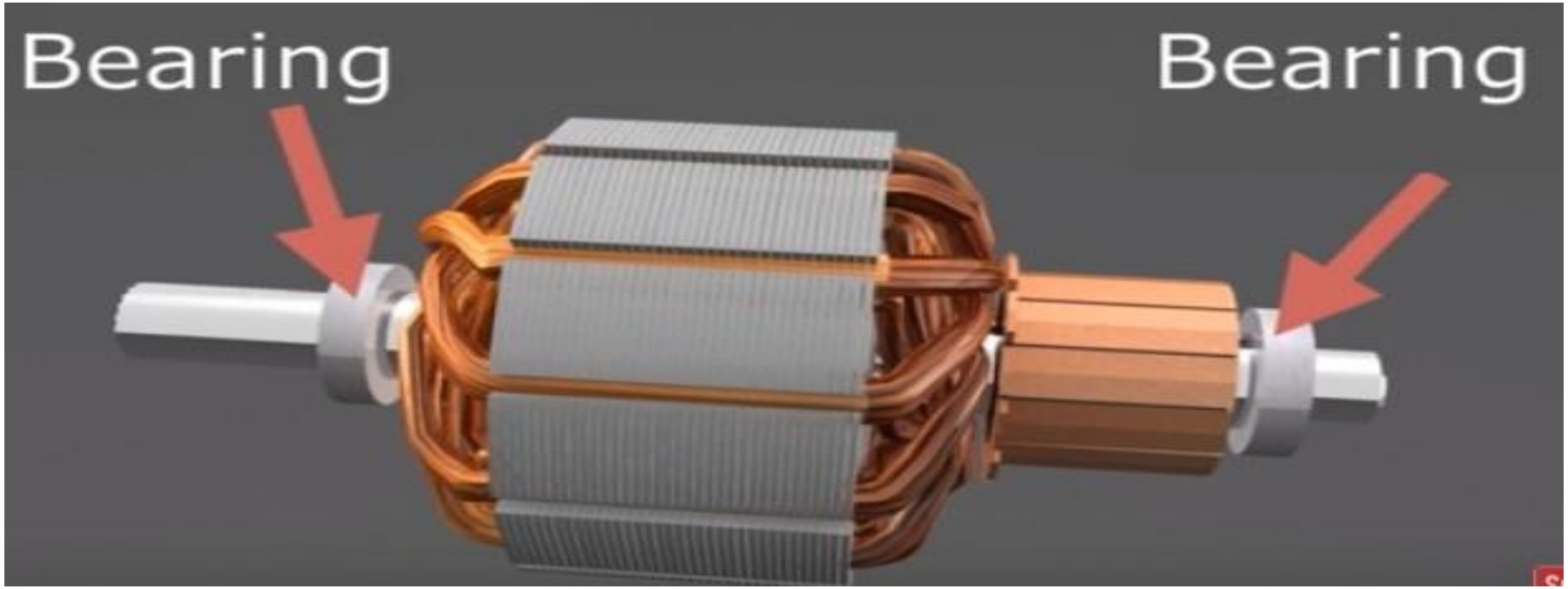
•This complete assembly is housed over a cylindrical shaft made up of **high quality steel**.



Miscellaneous parts Construction

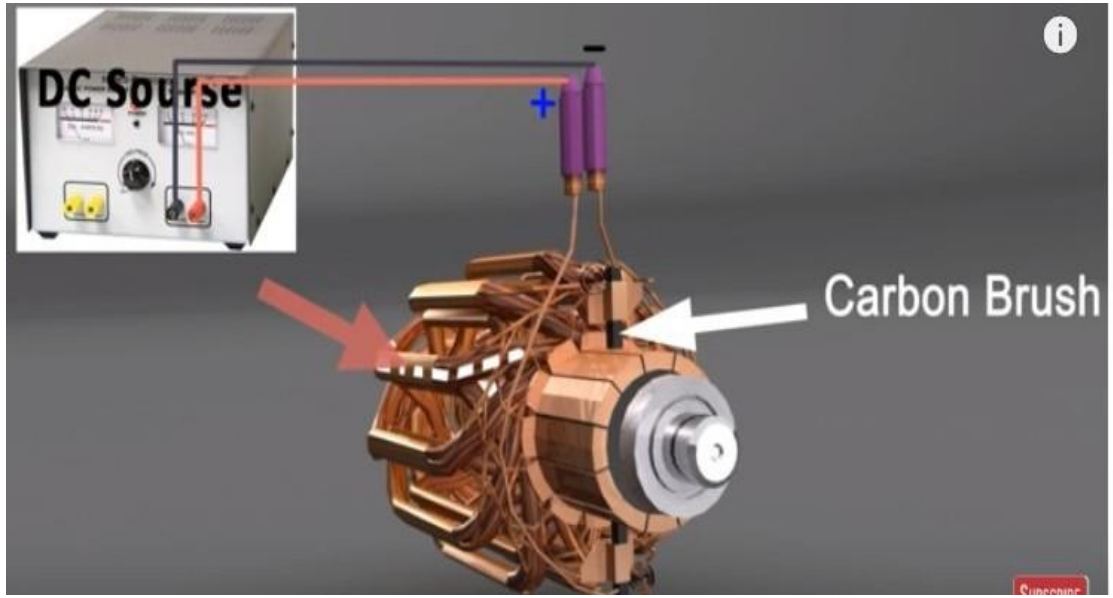
2.Bearing:

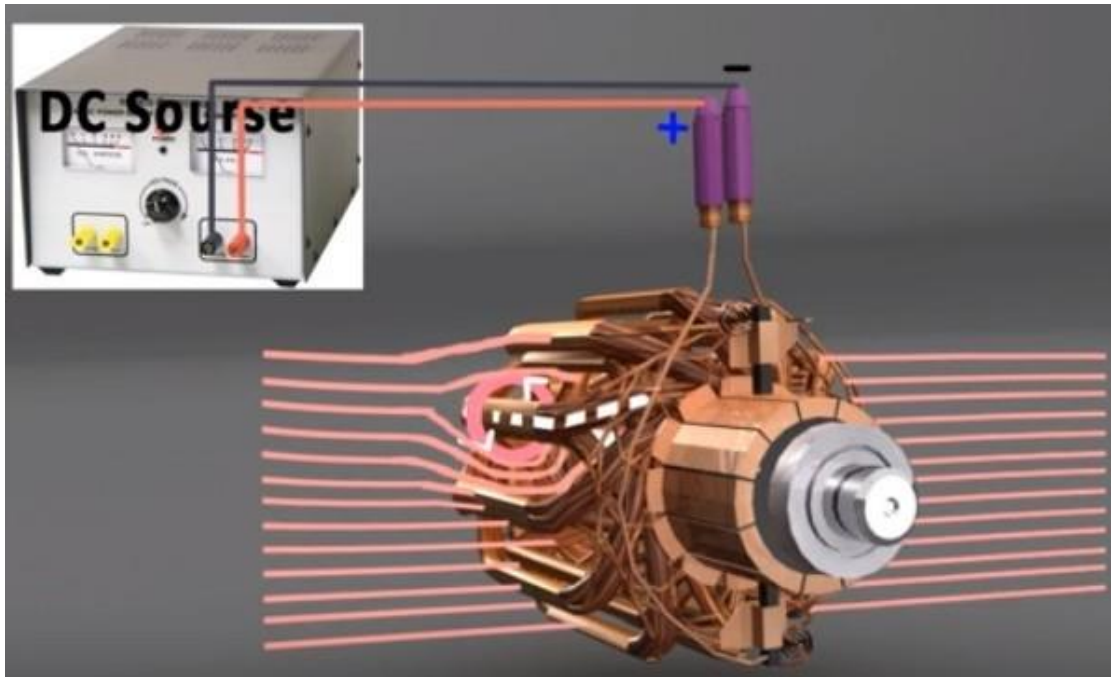
- Because of the bearings at both side of the shaft the rotor is capable of rotate between the field poles. The ball or roller bearings are fitted in the end housings. The friction between stationary and rotating parts of the motor is reduced by bearing. Mostly high carbon steel is used for making the bearings as it is a very hard material



Working Brief

- When electric current is forced to pass through the rotor conductors by a set of carbon brushes through commutator segments, it creates their own magnetic field which tries to distorts the magnetic field, created by the field pole.



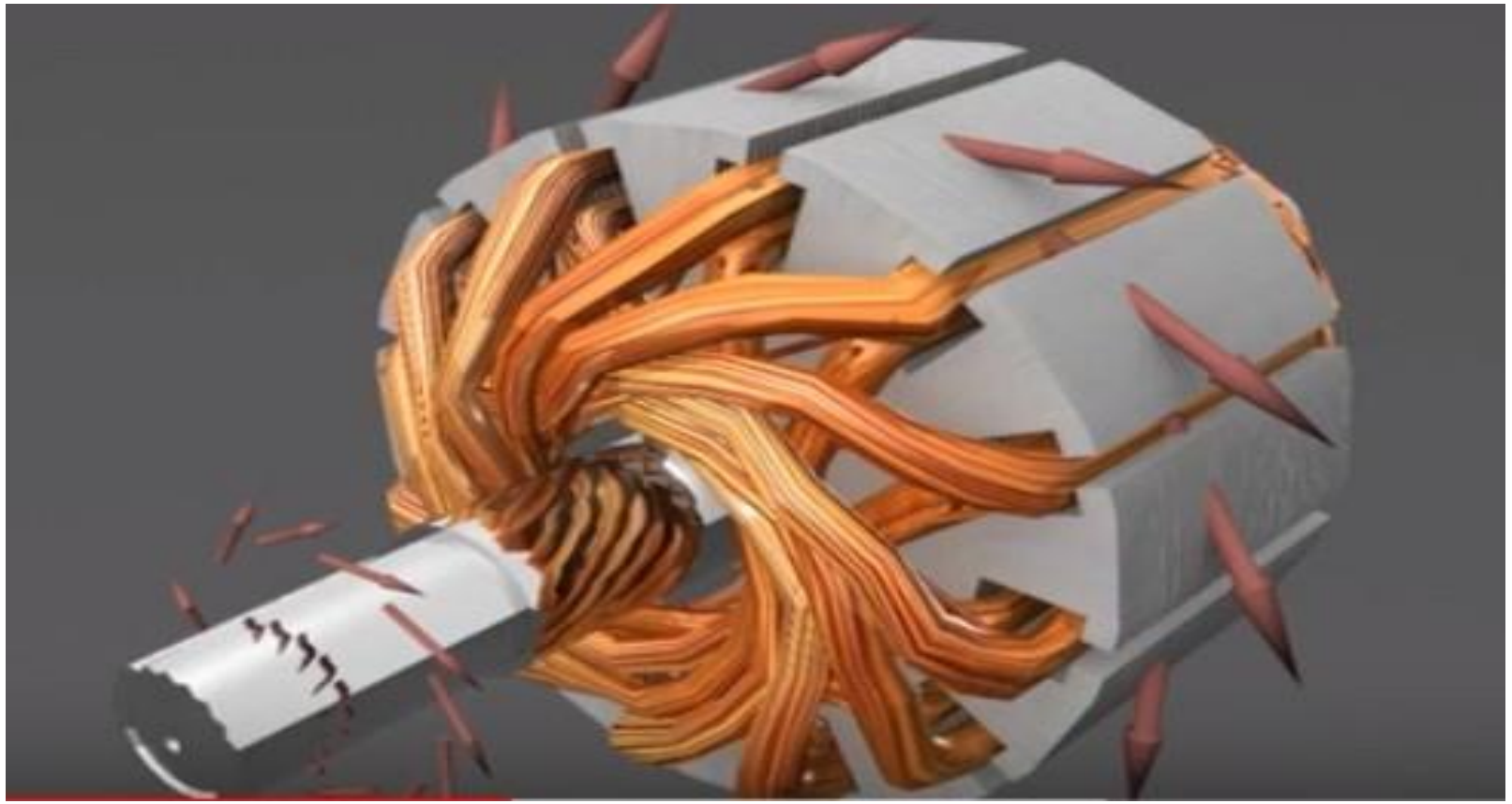


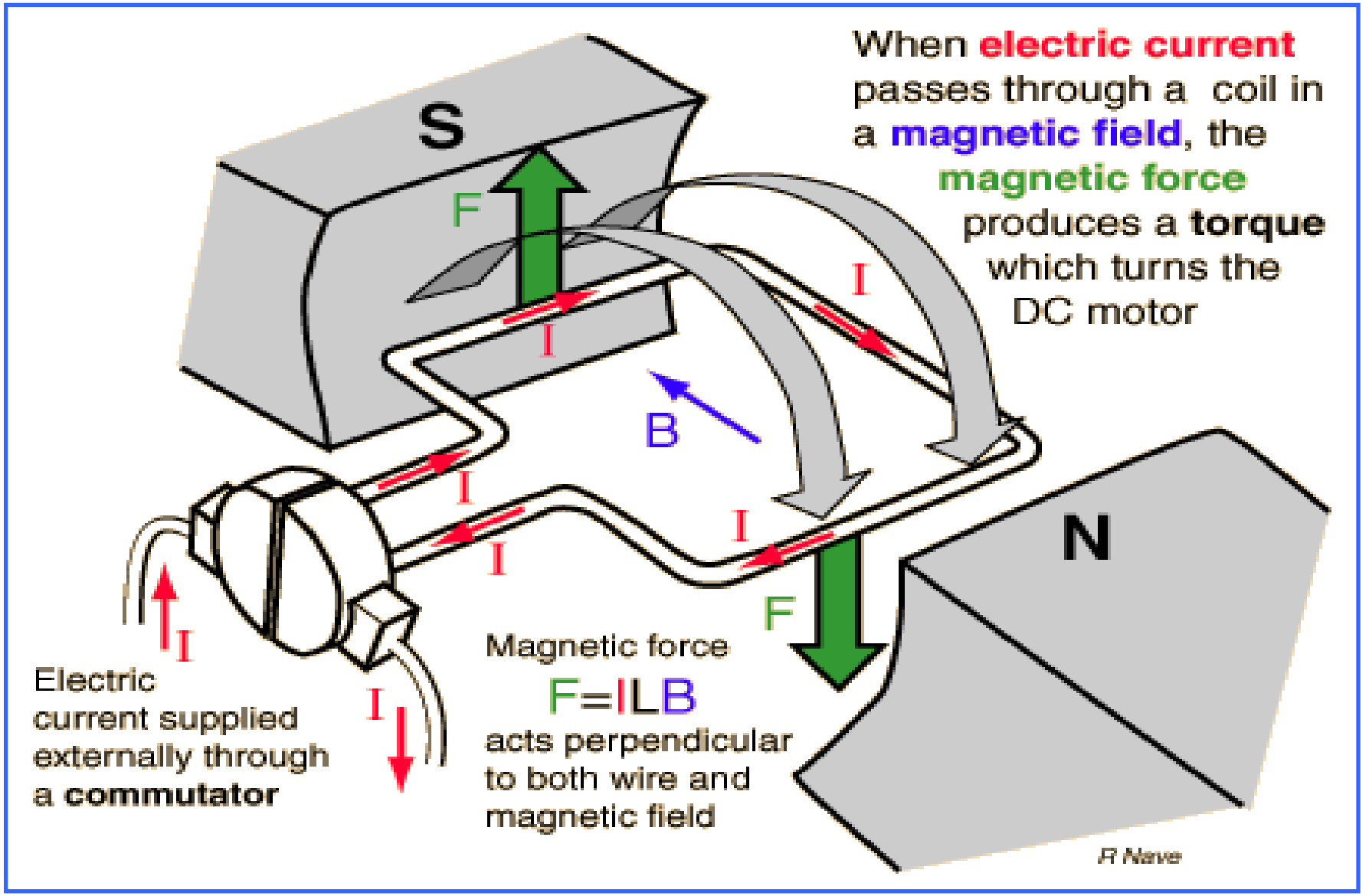
Working in Brief

- Due to interaction between two magnetic fields i.e magagntic field of main poles and the rotor conductors. Electromagnetic Forces act on the rotor conductors and these forces act tangentially on the rotor surface.

- Therefore a torque is produced at the rotor shaft and the rotor rotates.

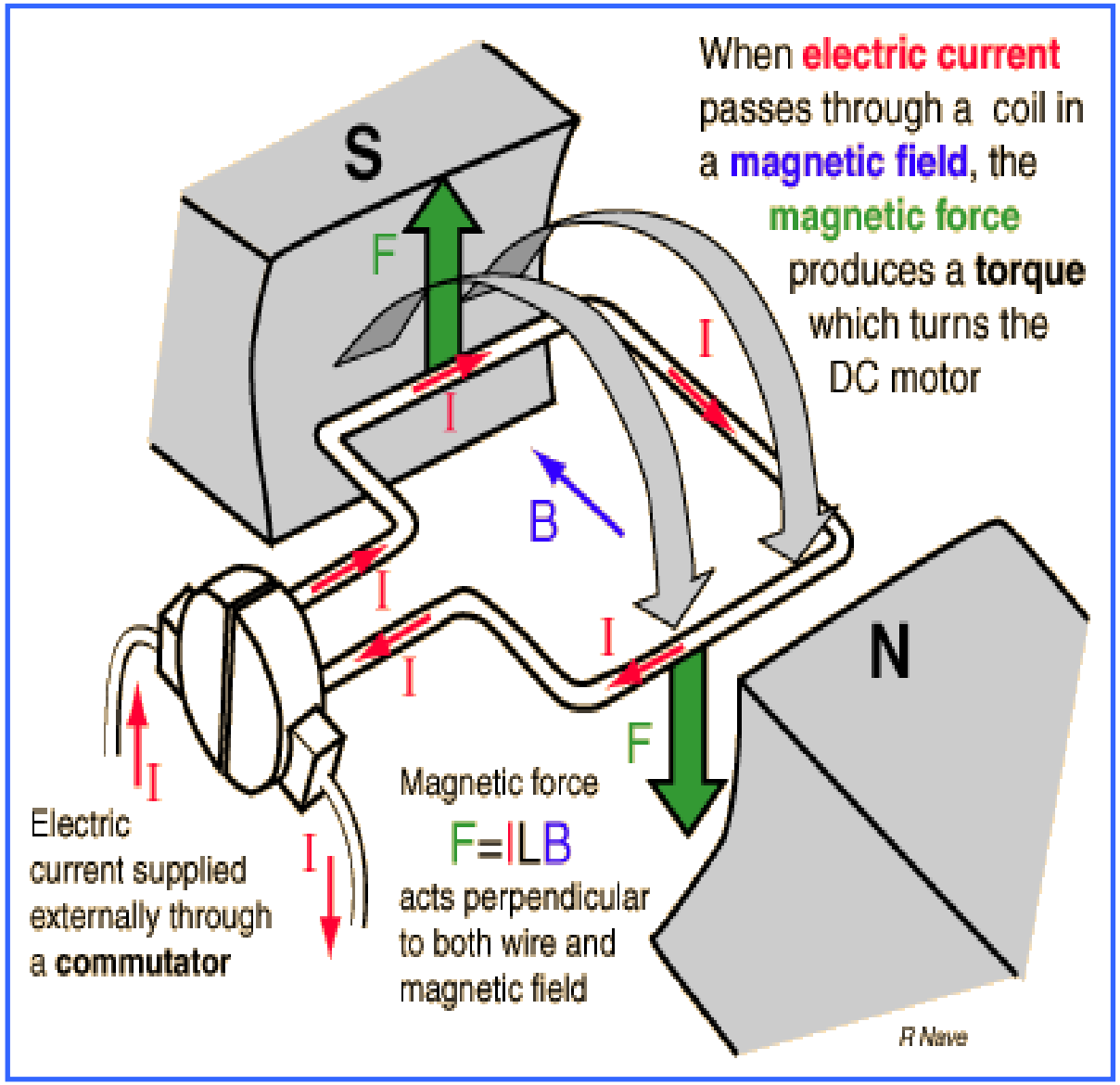
.




When electric current passes through a coil in a magnetic field, the magnetic force produces a torque which turns the DC motor
S
N
F
F
I
I
I
I
I
I
B
Electric current supplied externally through a commutator
Magnetic force
F=ILB
acts perpendicular to both wire and magnetic field
R Nave

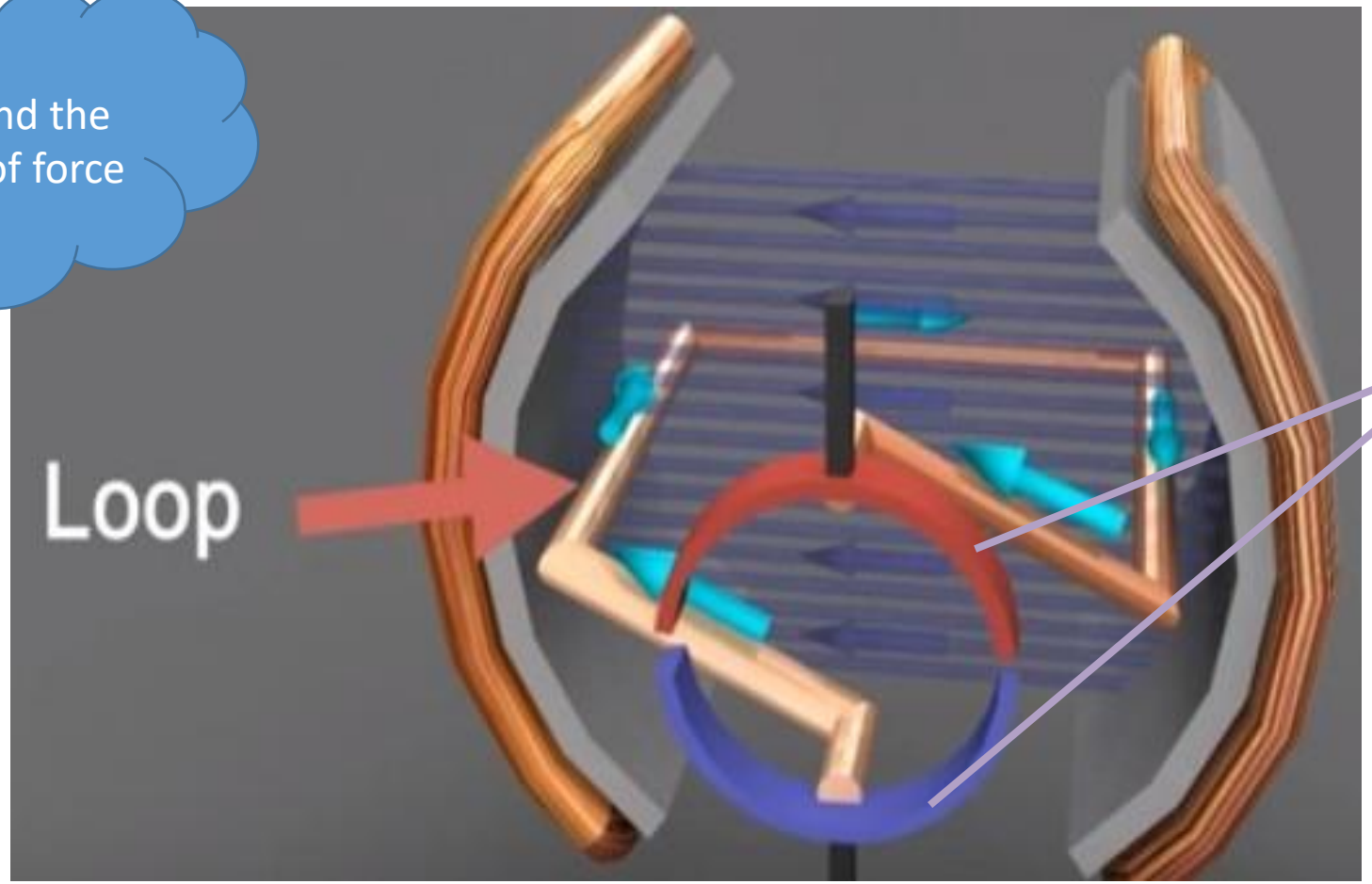
Working Principle of a DC Motor

- To understand the operating principle of DC motor we need to first look into its single loop constructional feature.
- The very basic construction of a DC motor contains a current carrying armature, connected to the supply end through commutator segments and brushes. The armature is placed in between north pole and south pole of a permanent or an electromagnet as shown in the diagram .
- As soon as we supply direct current in the armature, a mechanical force acts on it due to the electromagnetic effect of the magnet on armature conductors. This force produces torque which rotates the motor.
- we must have a clear understanding of Fleming's left-hand rule to determine the direction of the force acting on the armature conductors of DC motor.



- To understand the process more easily lets take a example of **single loop having a set of its own commutator segment**.

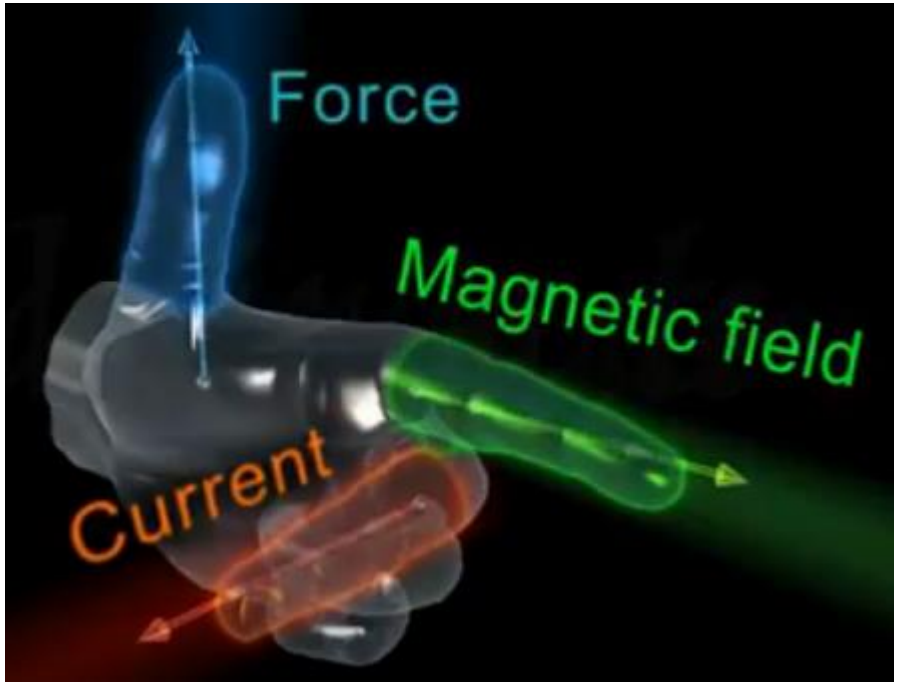
How to find the direction of force ?

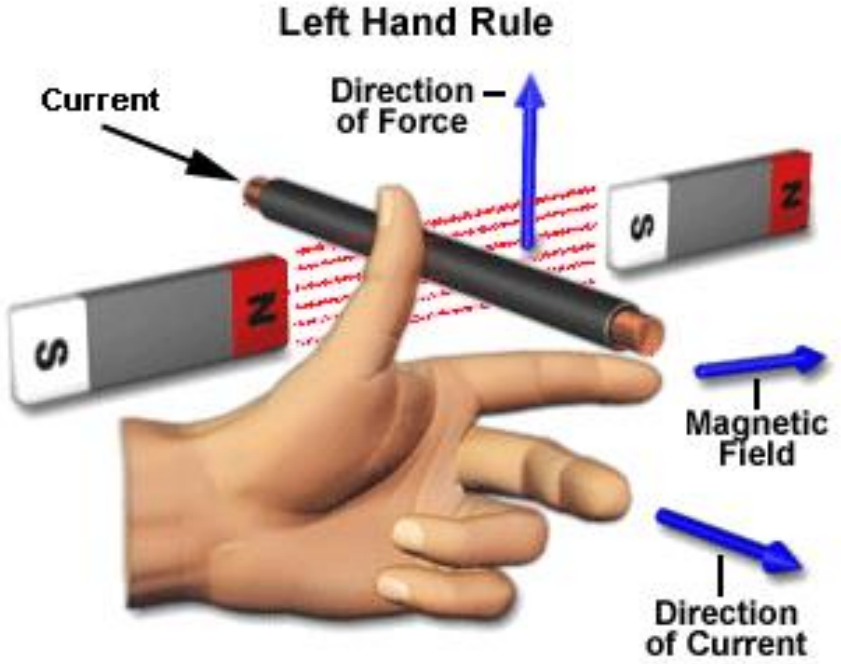


Fleming's Left Hand Rule

Statement:

whenever a current carrying conductor is placed inside a magnetic field, a force acts on the conductor, in a direction perpendicular to both the directions of the current and the magnetic field.





- During the rotation of loop you can find that commutator segments comes in contact with brushes of opposite polarity one by one.
- This way the conductor of left side always carry current in given direction right side in opposite direction.

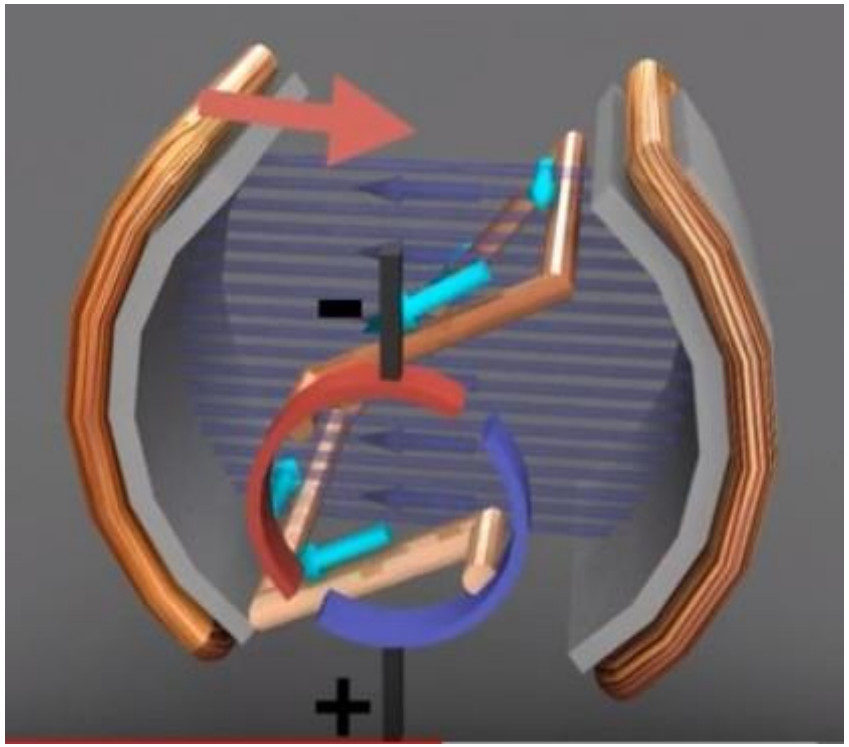
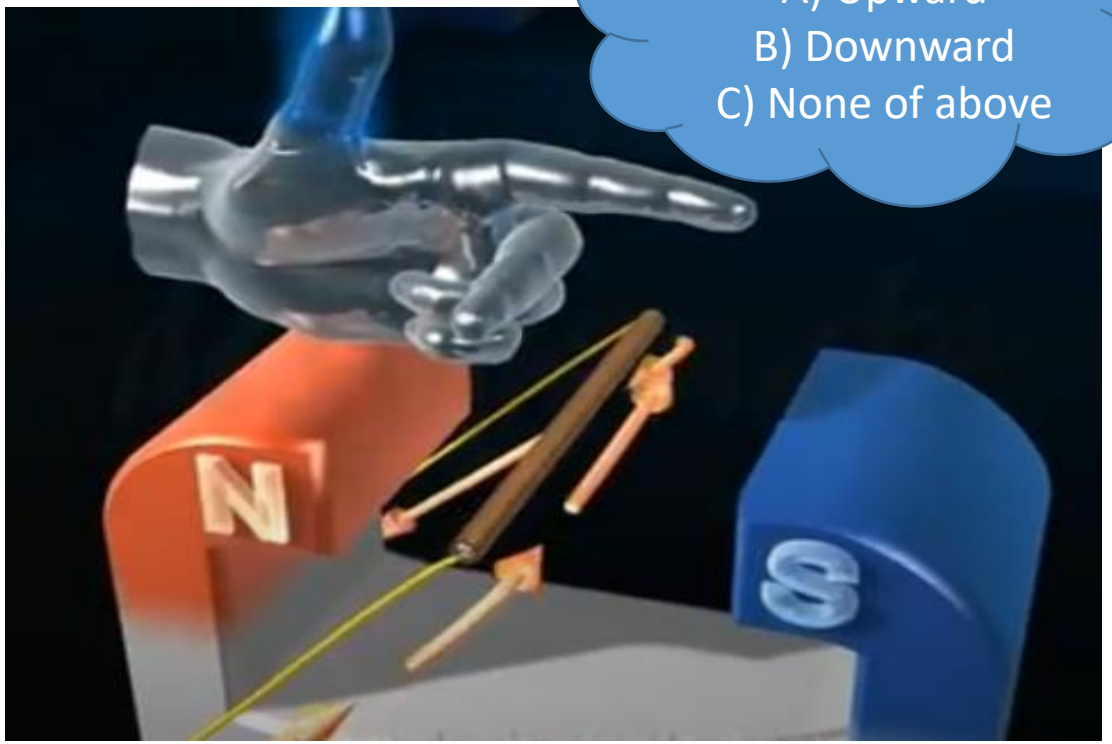


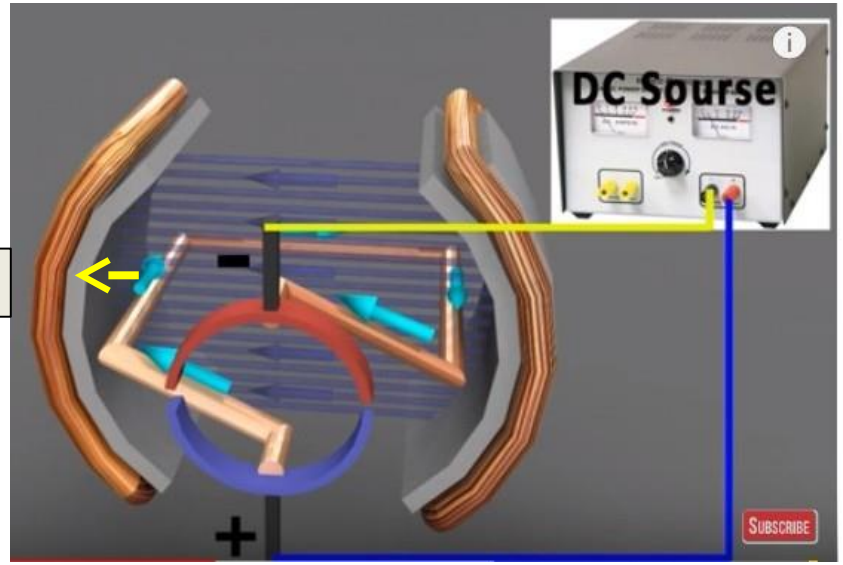
Figure 1

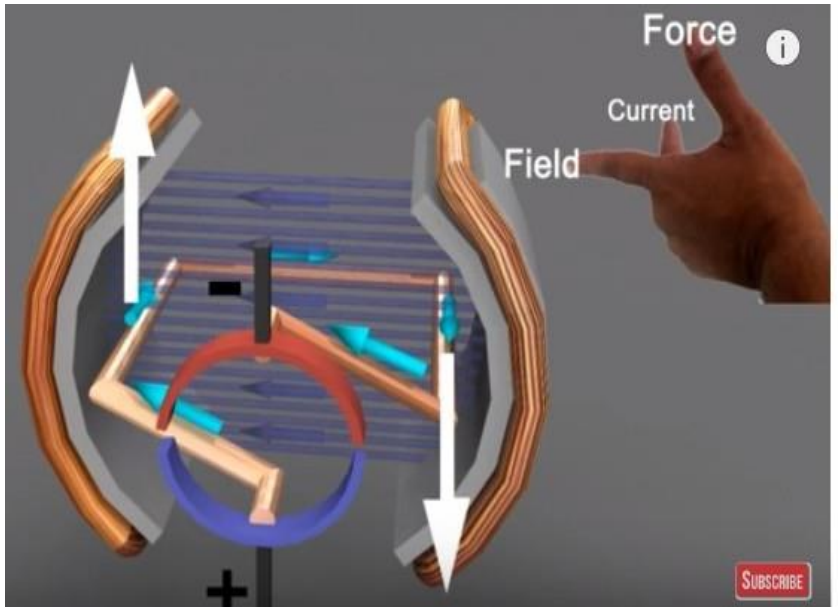


POLL: In figure 2
Direction of force?
A) Upward
B) Downward
C) None of above

Figure 2

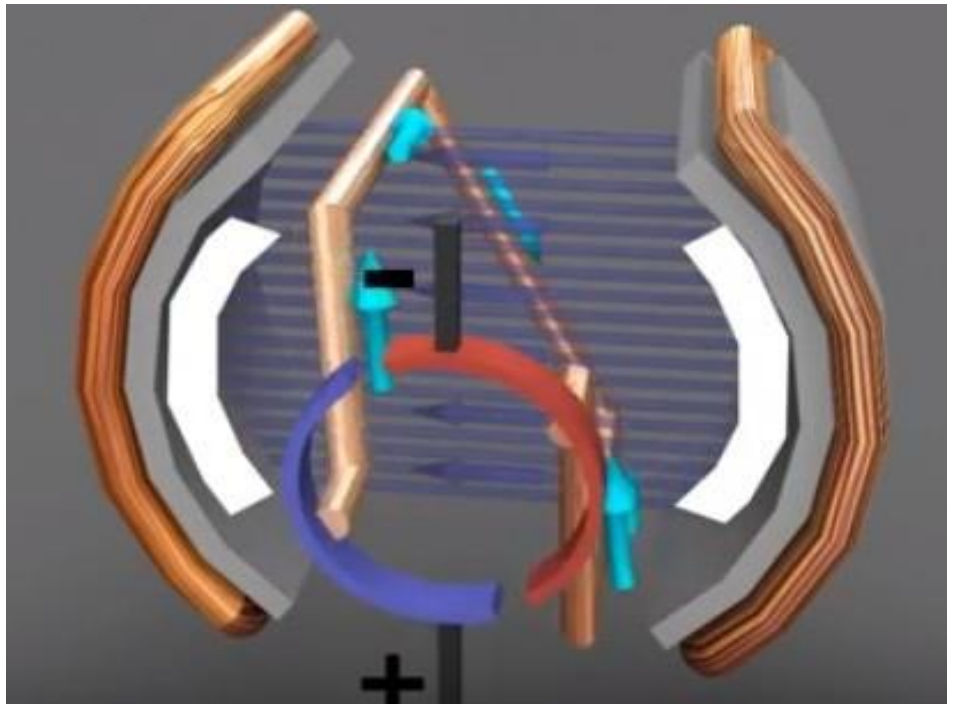
- Due to the DC voltage applied by an external DC source current will flow in the coil in given direction from positive to negative potential and by Fleming's left hand rule , we can find that one side of coil receive force in upward direction and other side will receive a downward force and which produces torque ,hence the loop rotates. This helps to maintain the continuous rotation of coil.

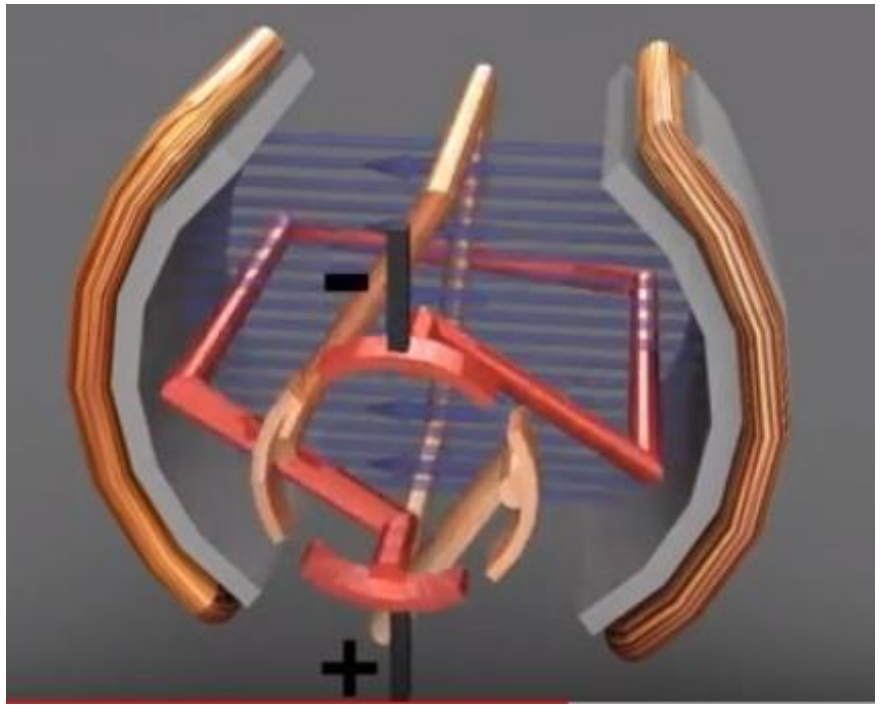




- We can also find that magnitude of force on the coil is maximum in this region after that, magnitude reduces considerably. This cause uneven torque and moment of rotor.
- **To make "maximum torque" always available at the shaft of rotor multiple number of coils with a pair of commutator segments are placed in the rotor**.

Problem with one loop (one coil)



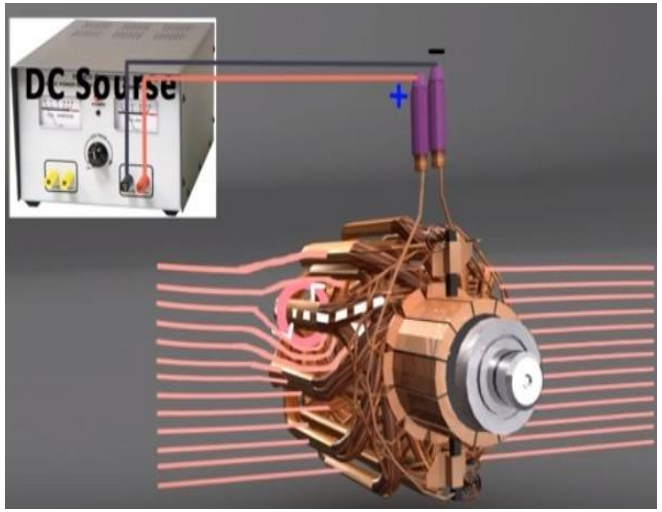


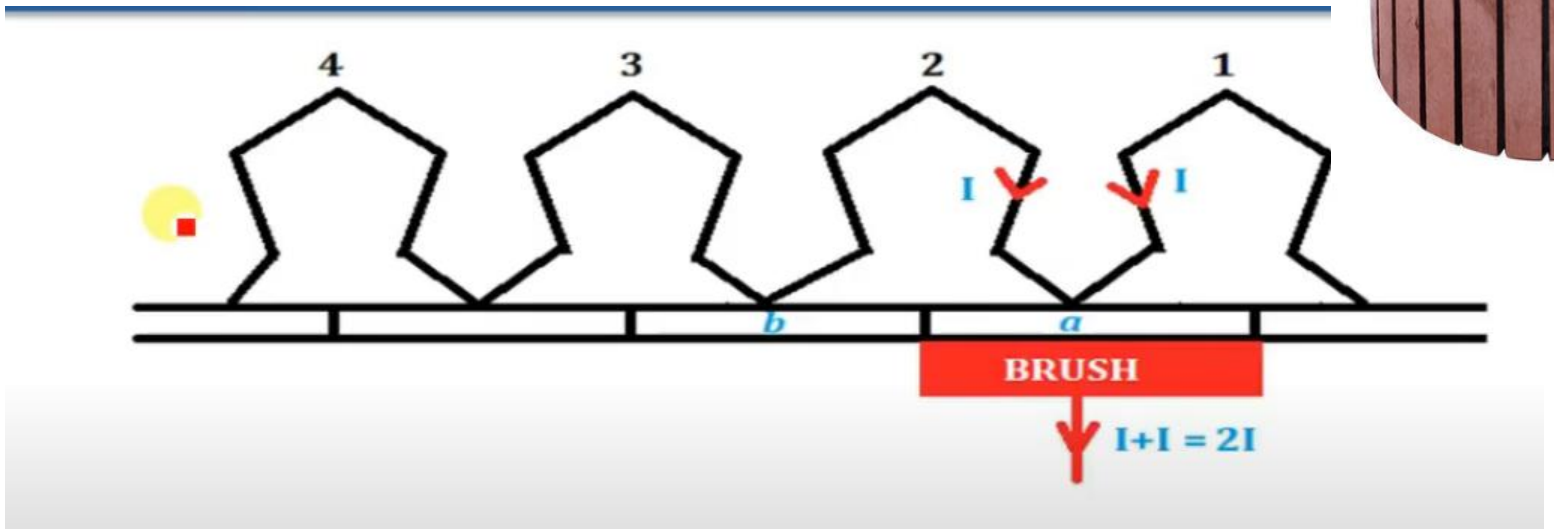
QUICK QUIZ (POLL)

Which of the following rule is used to determine the direction of rotation of D.C motor?

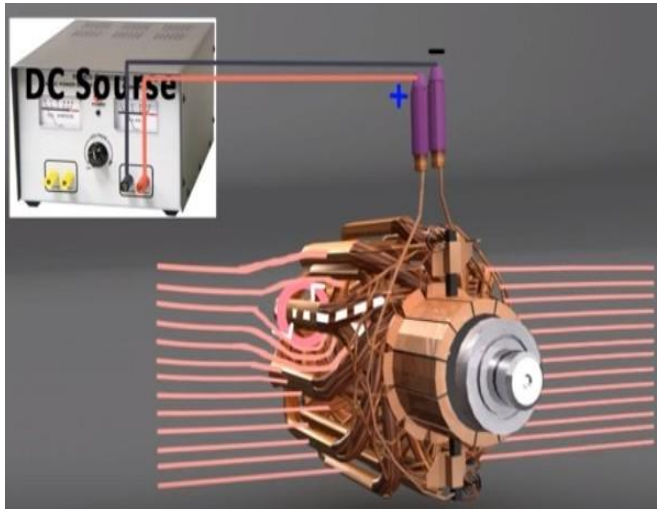
A. Coulumb's Law
B. Lorentz Law
C. Fleming's Left Hand Rule
D. Fleming's Right Hand Rule

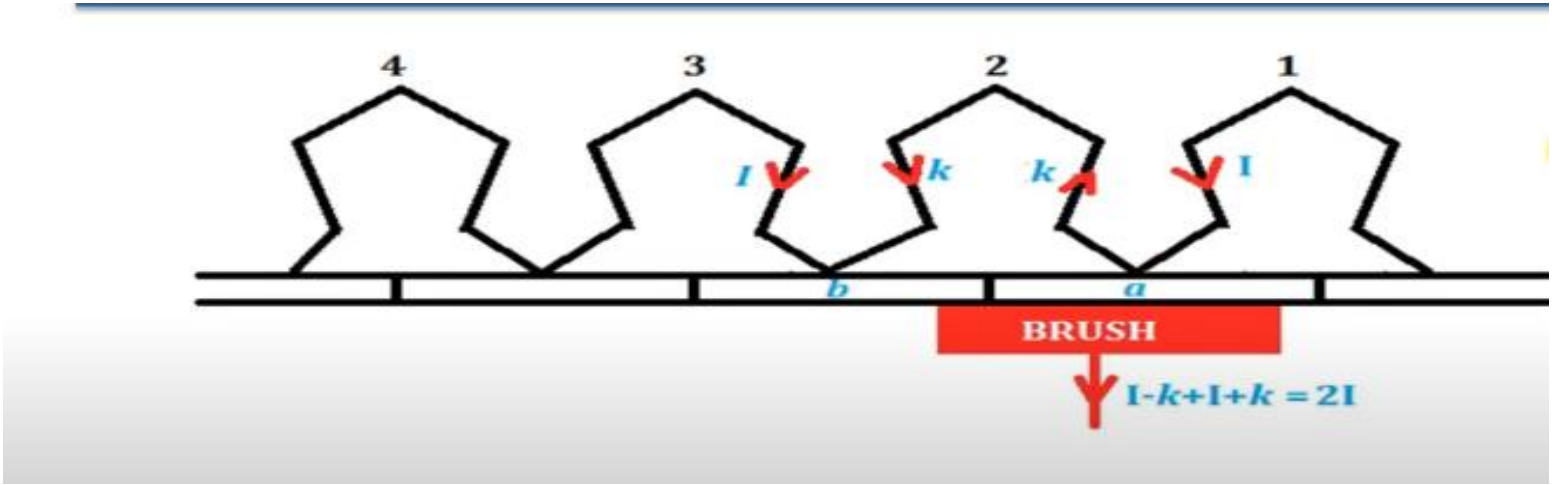
Working of Commutator



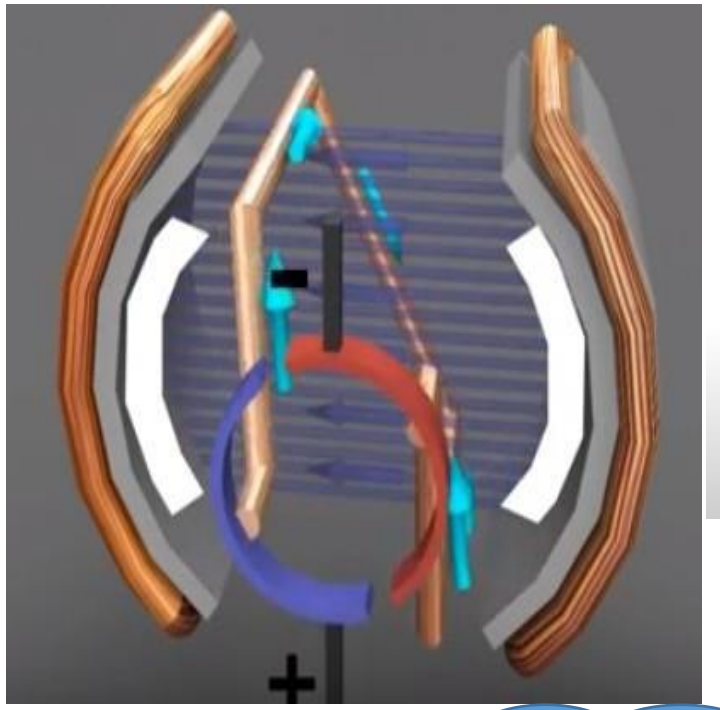


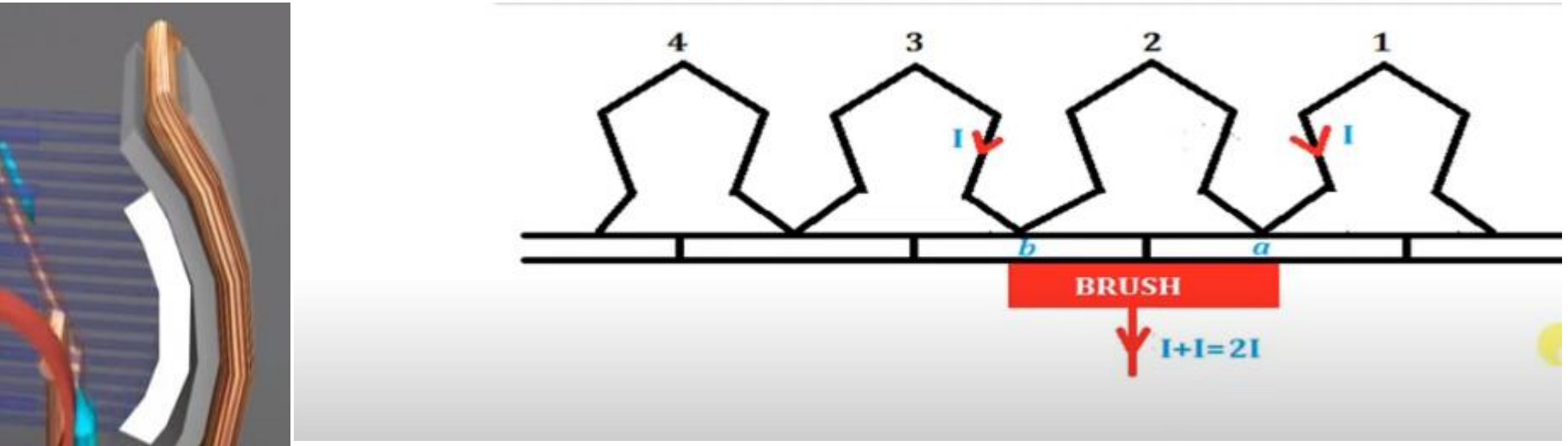
Working of Commutator





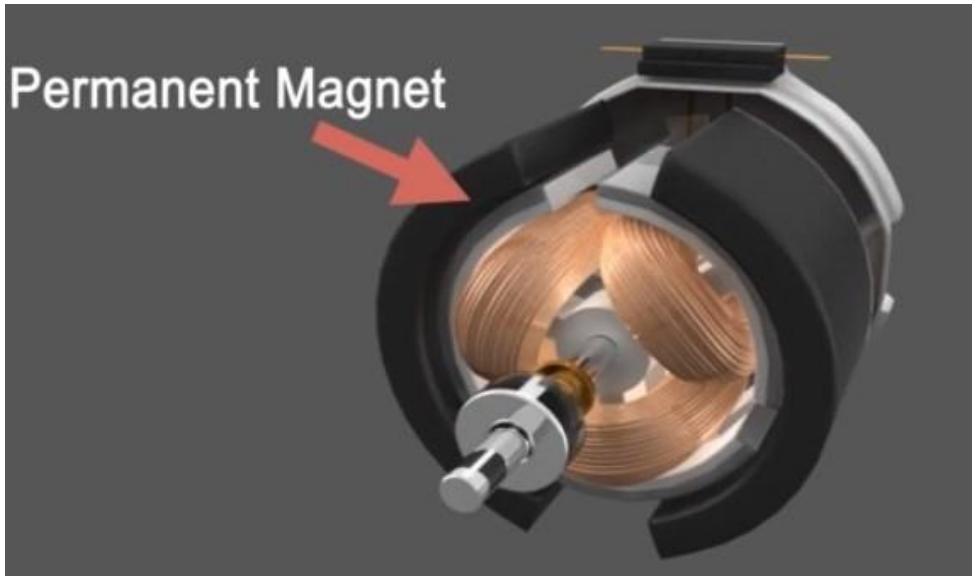
Working of Commutator

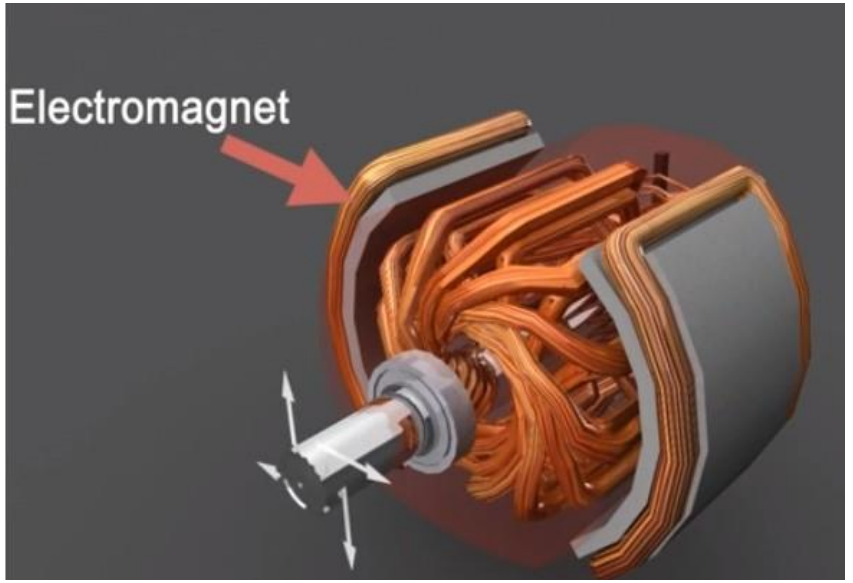




For conductor 2 , when coil is perpendicular to field lines then what should be the current

- In small DC motor permanent magnet can be use to create static magnetic field, but they can loose their magnetism due to heating, vibration, or aging, that's why in higher rating motor electromagnets are used and their magnetic field density can be controlled to control output torque.

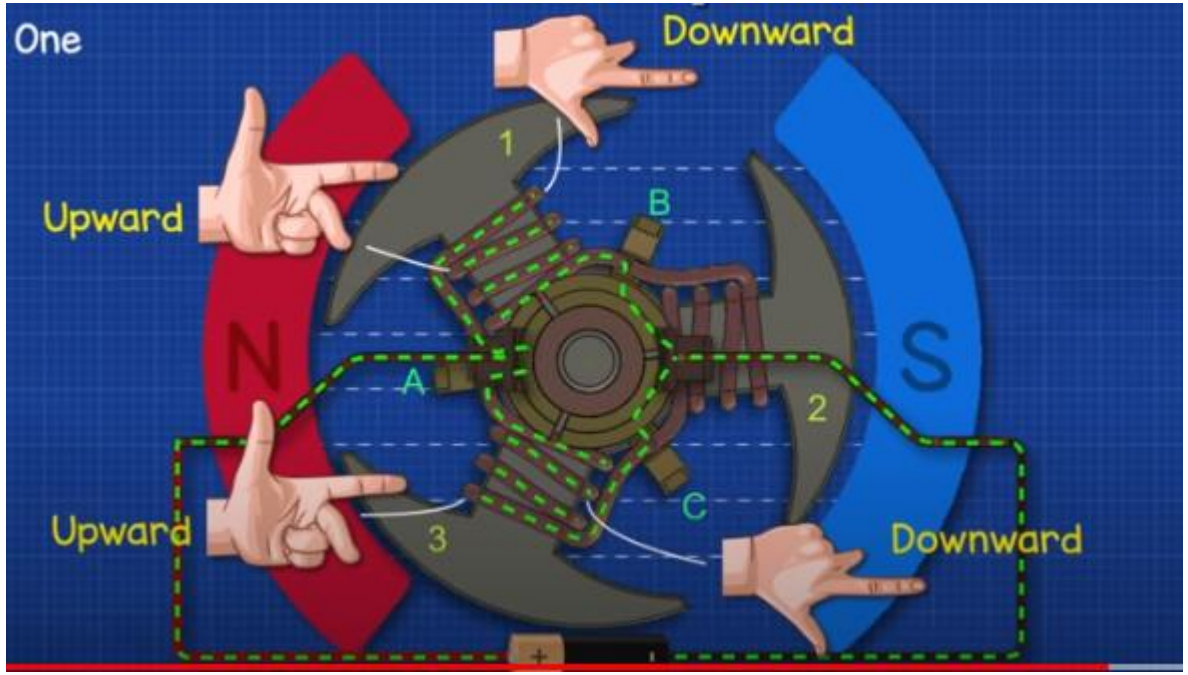




POLL

Which part will surely tell that given motor is DC motor and not an AC type?

a) Winding
b) Shaft
c) Commutator
d) Stator


One
Downward
Upward
1
B
N
A
S
2
C
Upward
3
Downward
+

Back EMF of DC Motor

- When the armature of a d.c. motor rotates, the windings or conductors on the armature also rotate in the magnetic field. According to the " Faraday's Laws of Electro-Magnetic Induction " e.m.f. is induced in the conductors, whose direction, as found by " Fleming's Right Hand Rule ", is in opposition to the applied voltage. The emf induced in the armature winding is in the opposite direction, hence it is referred to as back e.m.f. Eb of the motor. This back emf tries to oppose applied voltage V, but it has to drive armature current Ia against the opposing of back emf Eb.
- Recall:

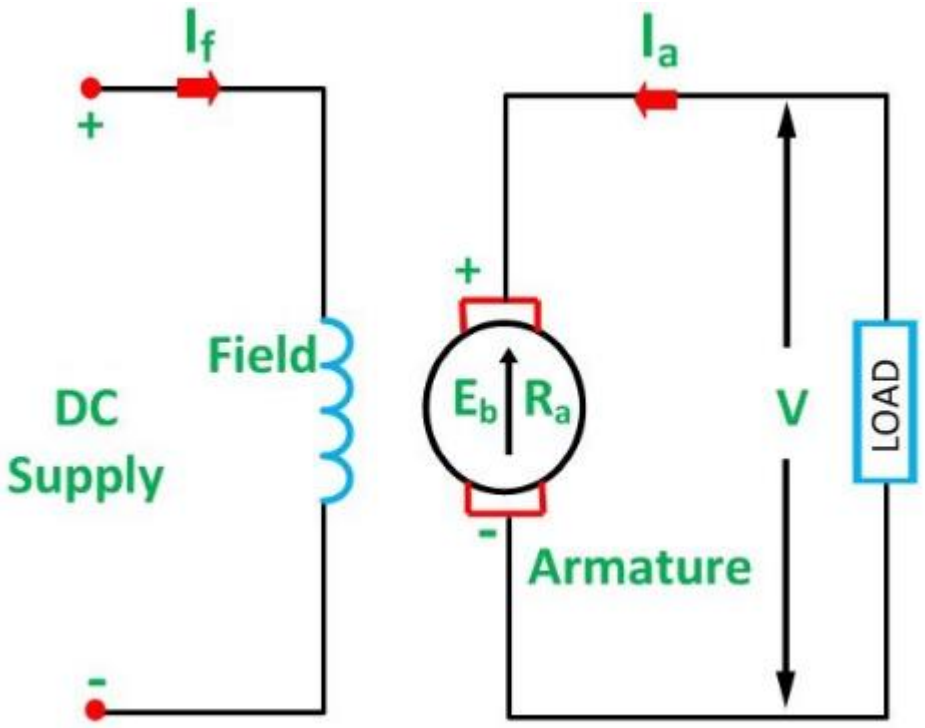
$$V = E + I_A R_A$$

Implies, $I_A = \frac{V-E}{R_A}$

DC Machine as a Motor

- The current Ia flows in the opposite direction to that of the generated emf, and the terminal voltage V is more than the emf E due to the armature circuit voltage drop. Thus we have:

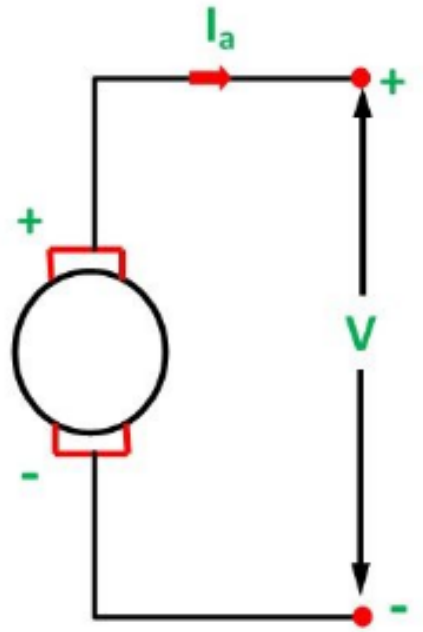
$$V = E + I_A R_A$$



DC Machine as a Generator

- The current Ia flows in the same direction as the generated emf, and the terminal voltage V is less than the emf E due to the armature circuit voltage drop. Thus we have:

$$V = E - I_A R_A$$



QUICK QUIZ (POLL)

What will happen if the back emf of a DC motor vanishes suddenly?

a) The motor will stop

b) The motor will continue to run

c) The armature may burn

d) The motor will run noisy