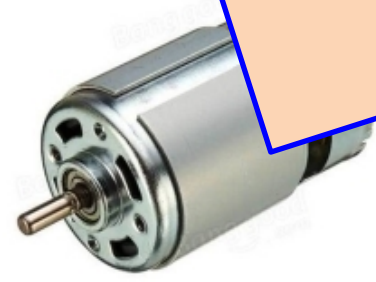


F

N

E

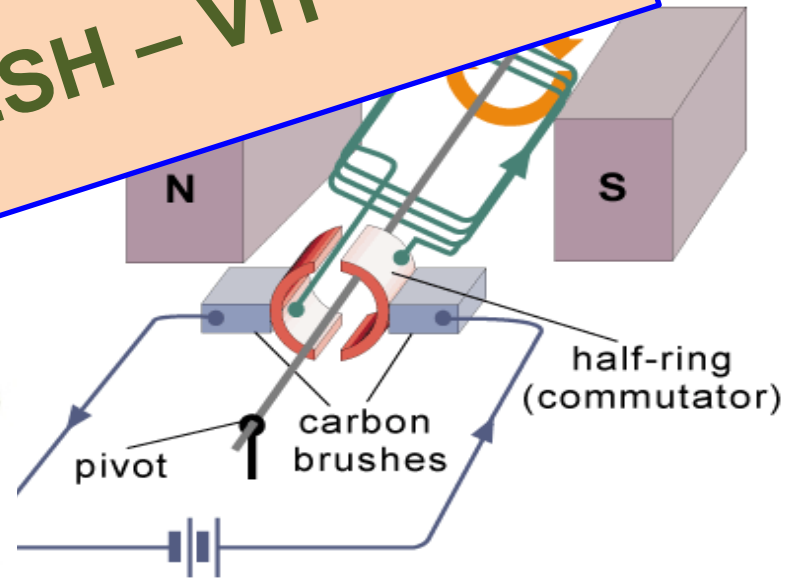
Actuators – 3.3
DC Brush Motors
FY – DESH – VIT



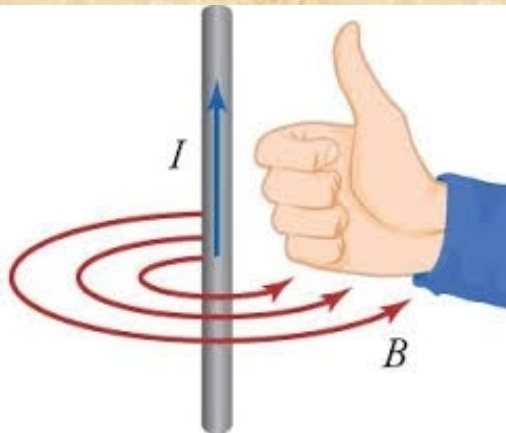
DC Motor



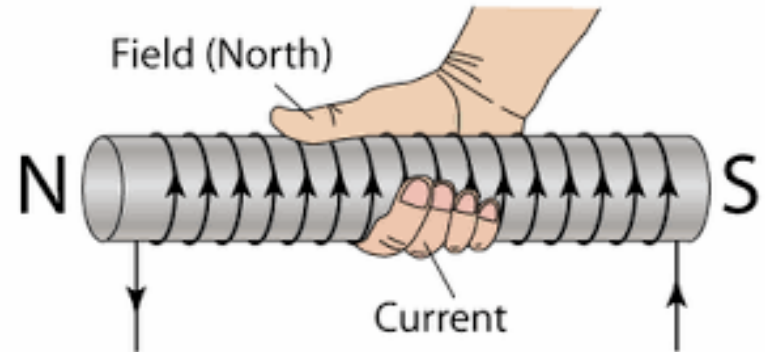
AC Motor



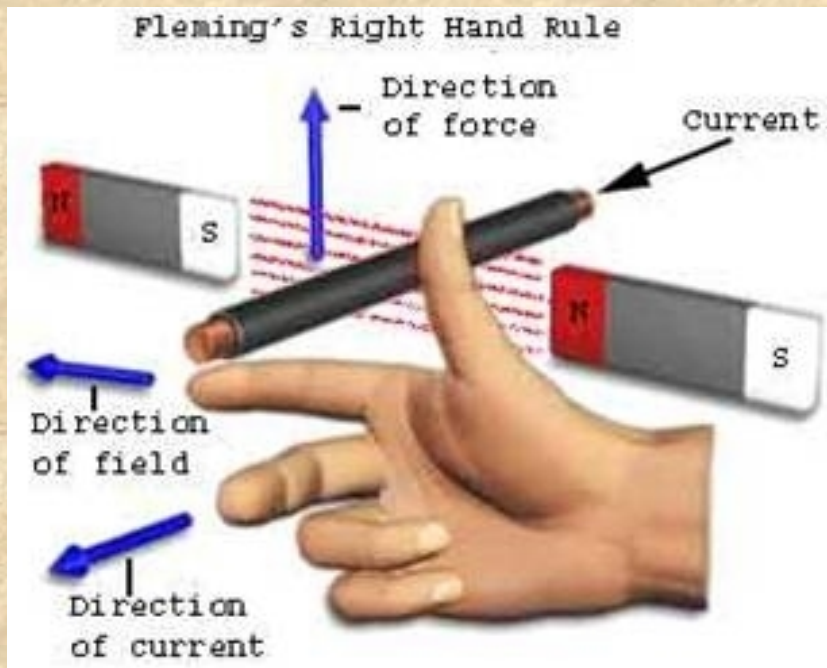
1) Right hand thumb rule – Relation between Magnetism and Current



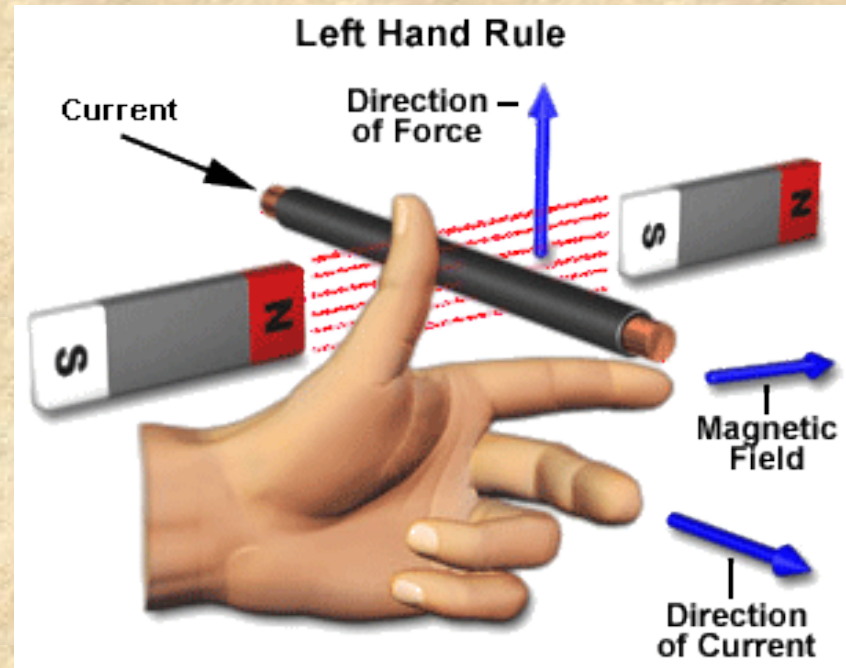
**Thumb is for
Current OR
Flux ?
Which figure is
correct ?**

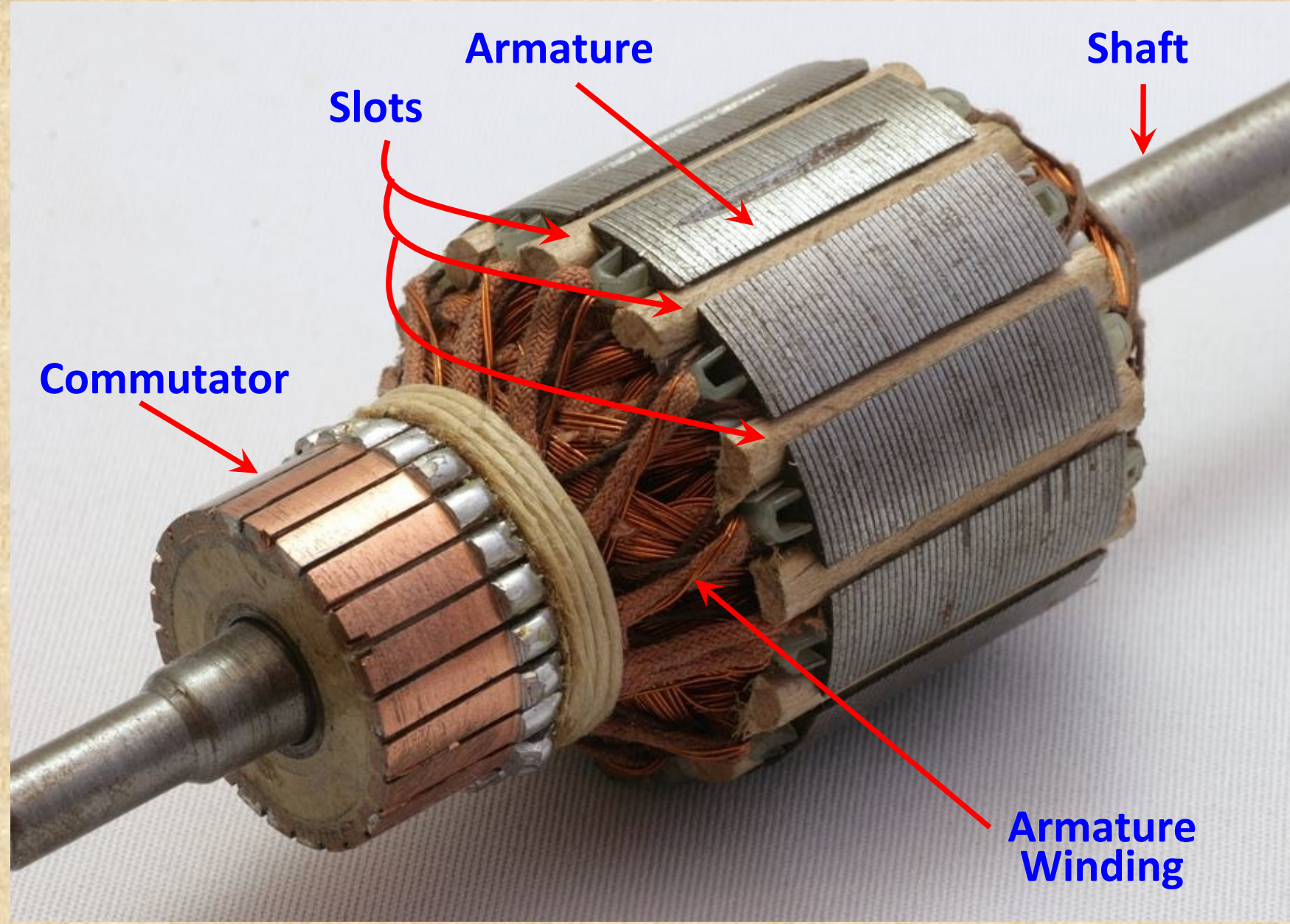


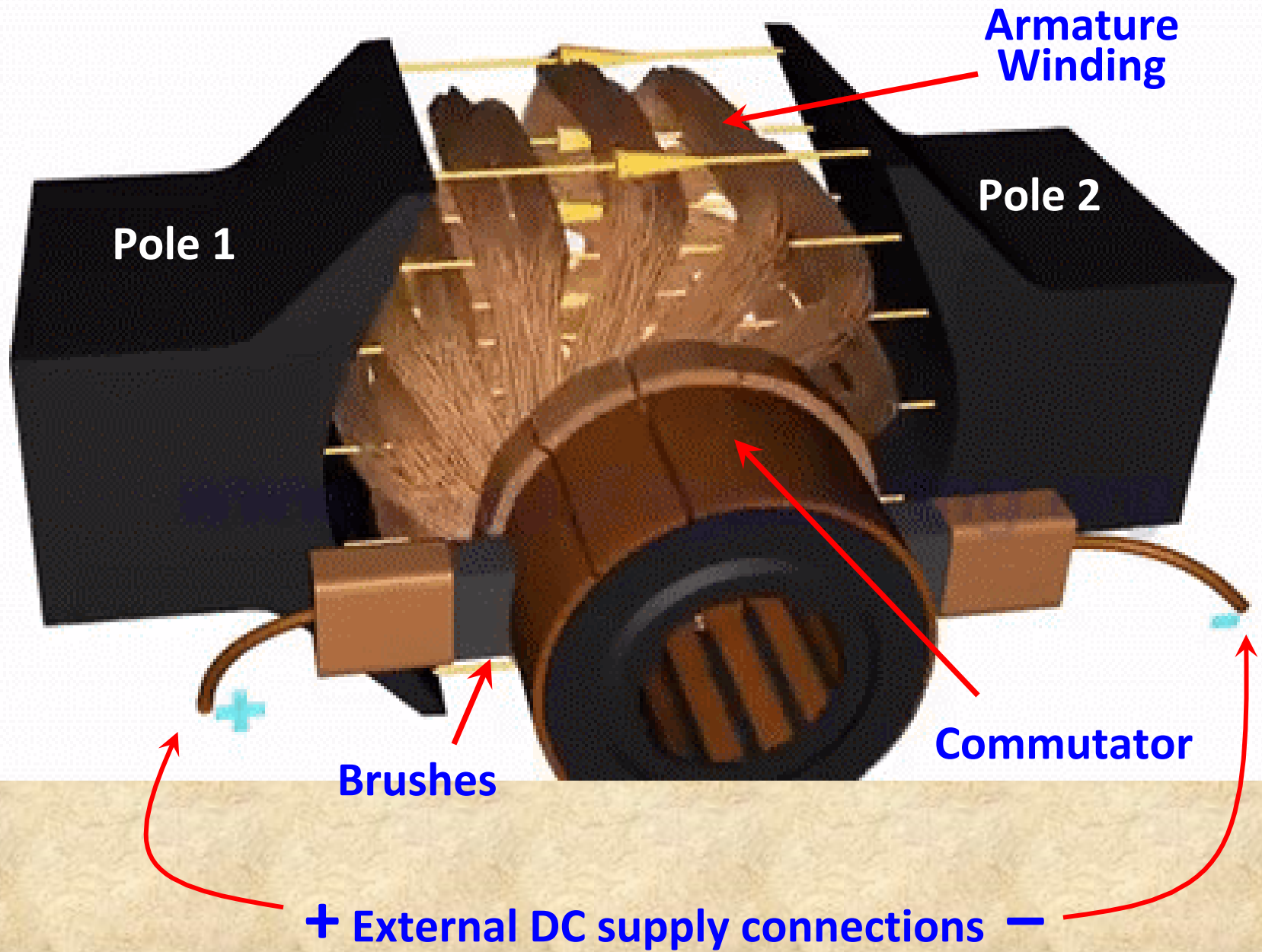
2) Right hand rule – Generating action

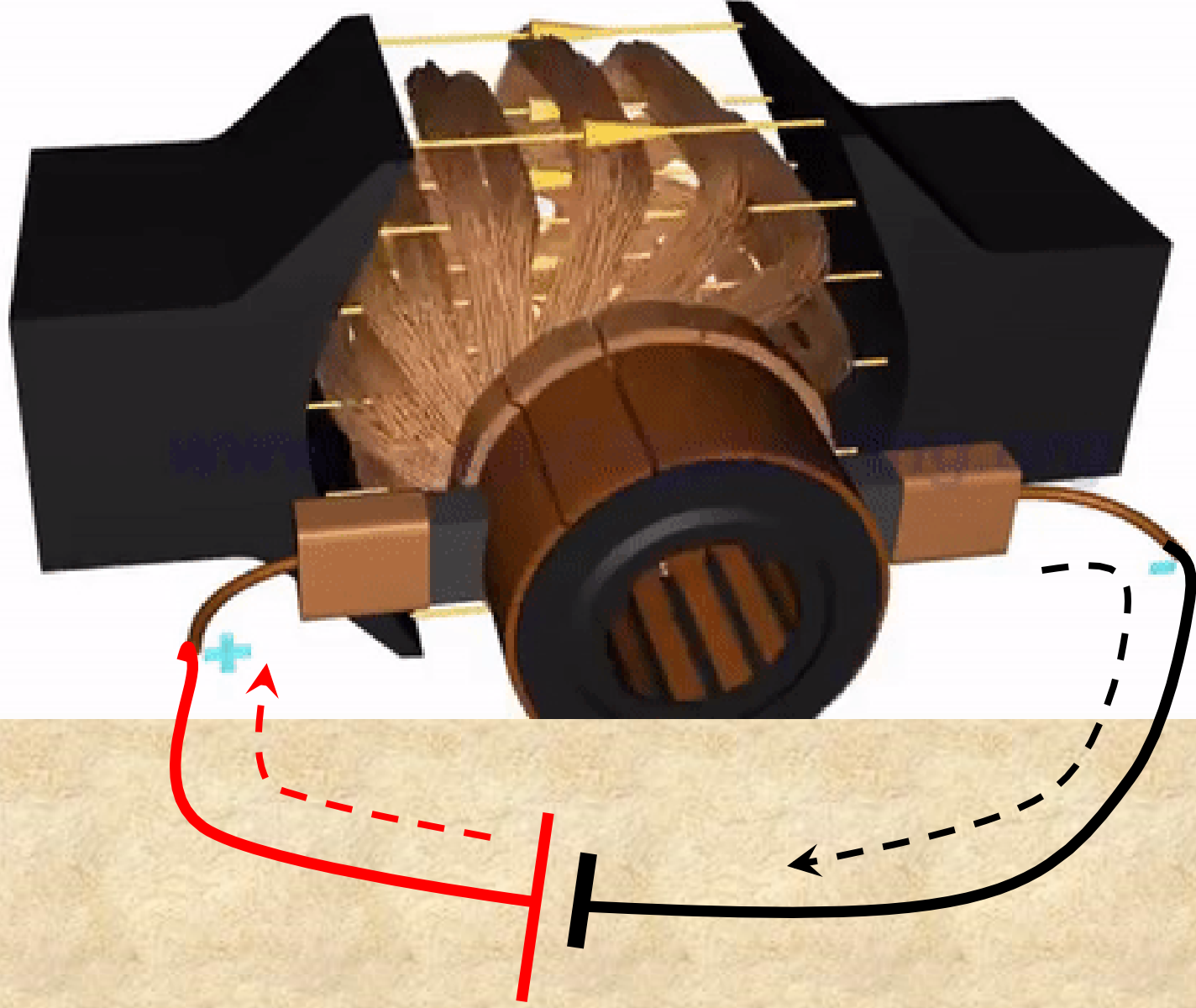


3) Left hand rule – Motoring action

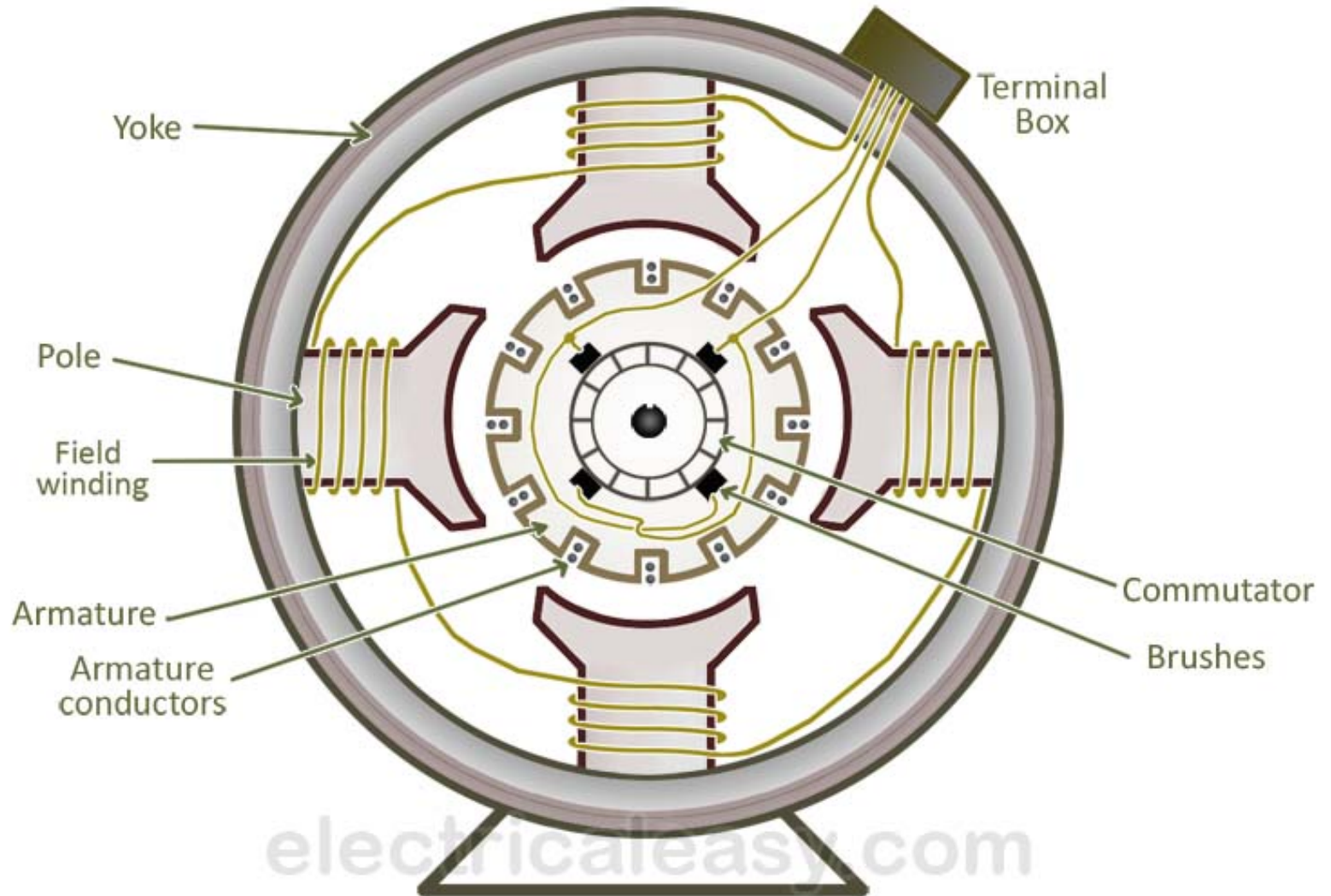




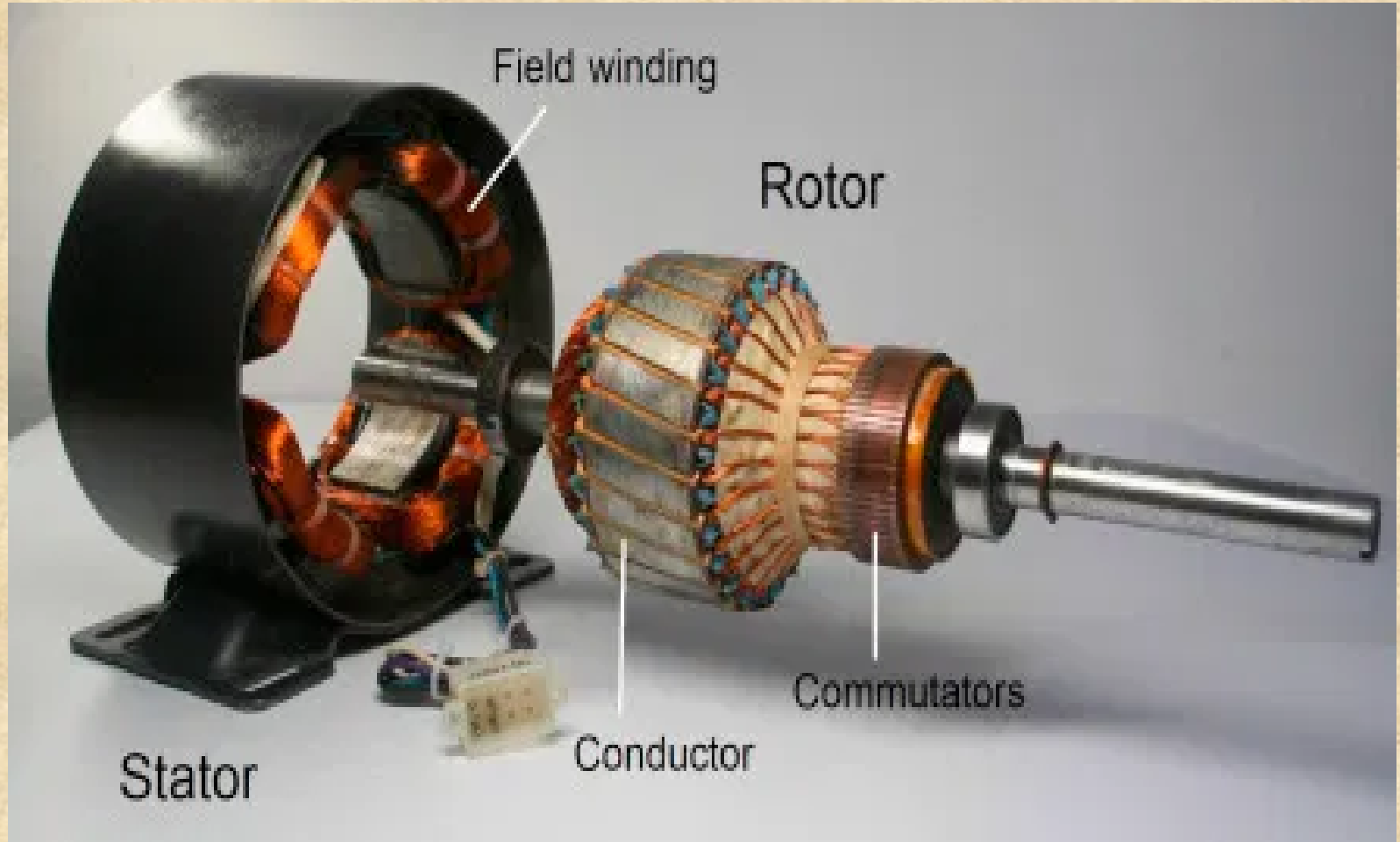




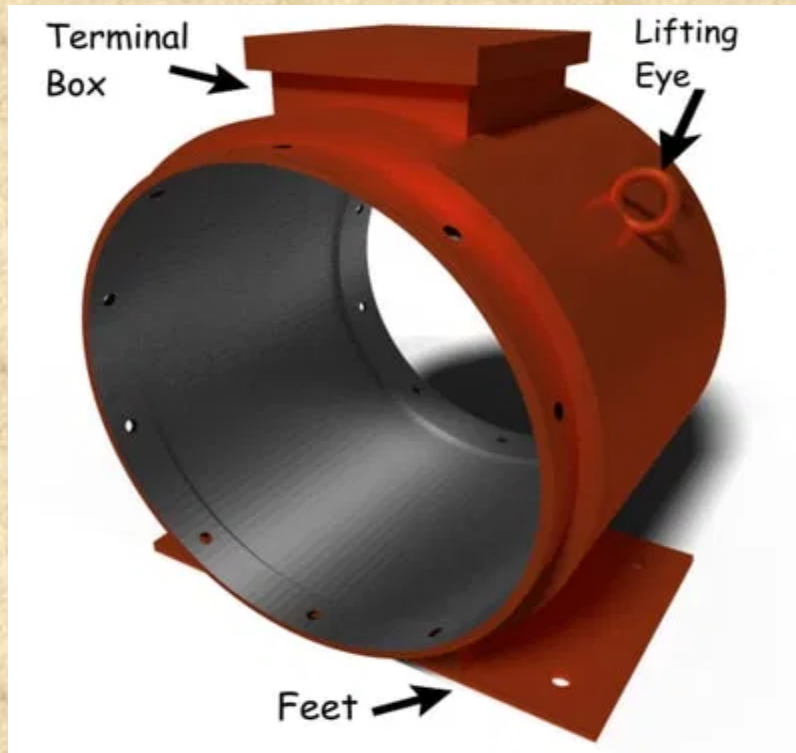
Construction of DC Machine



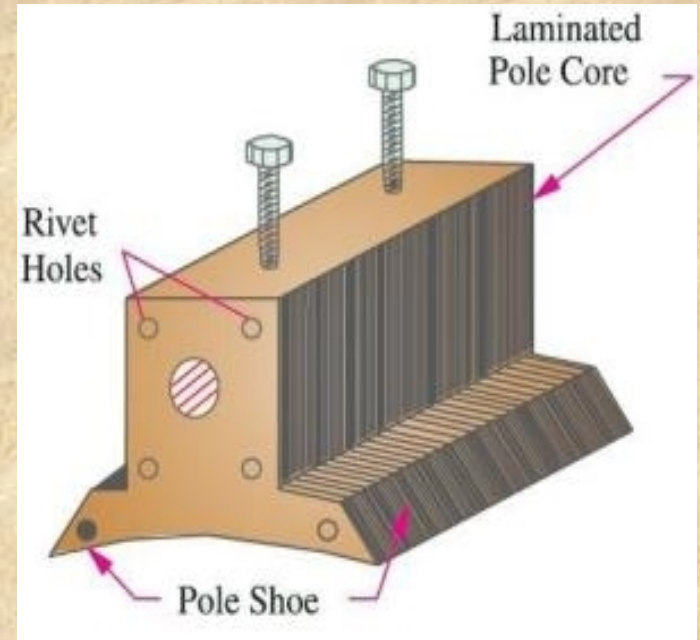
Construction of DC Machine



Construction of DC Machine

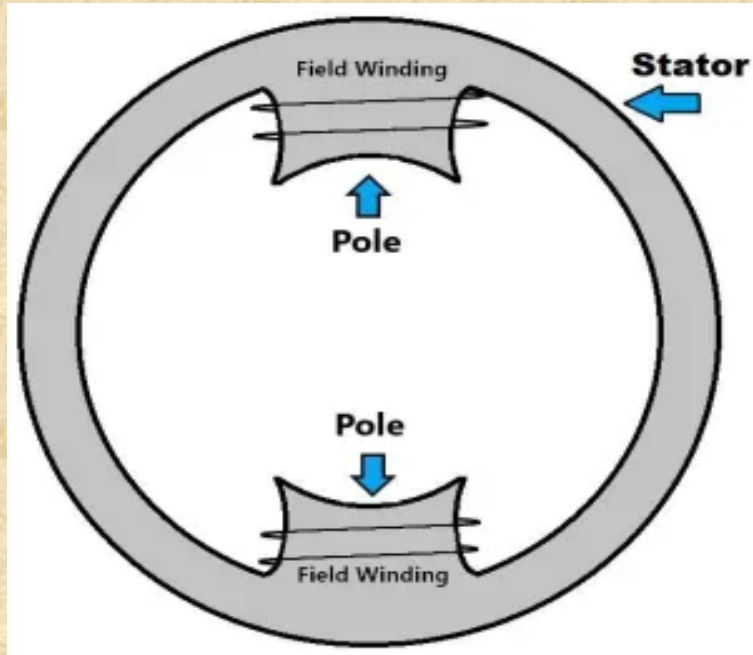


YOKE

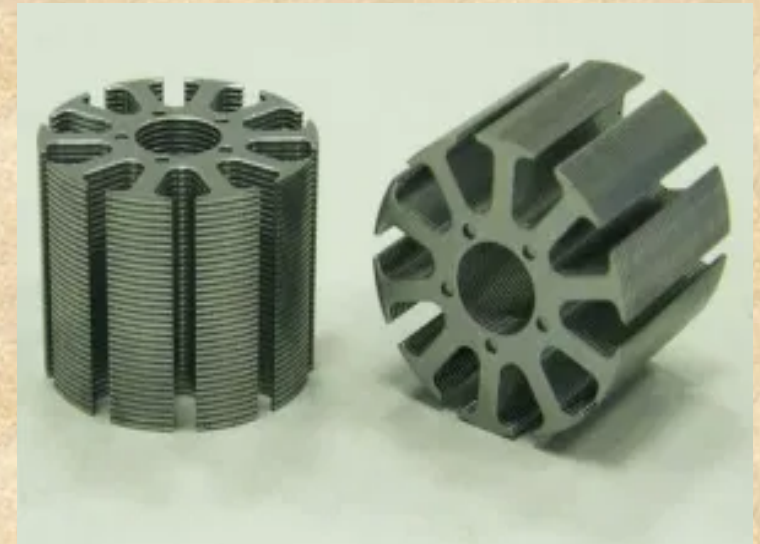


POLE CORE AND POLE SHOE

Construction of DC Machine

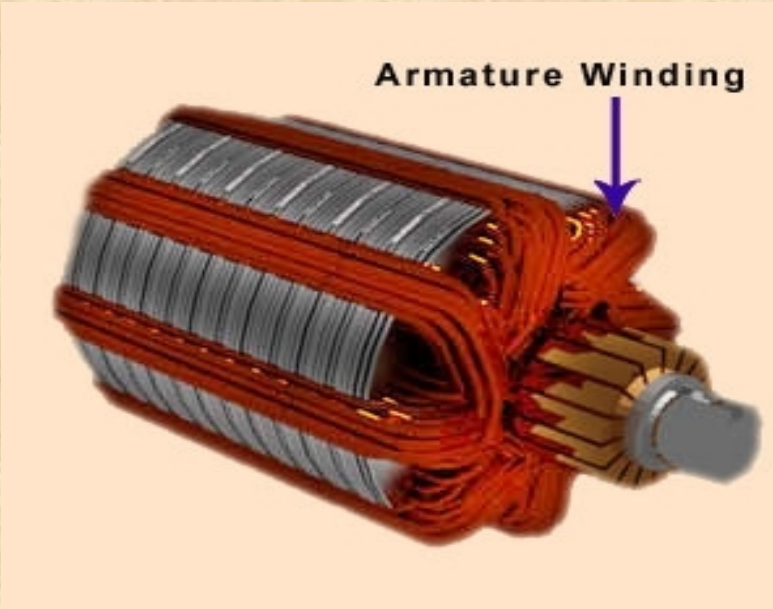


POLE WINDING OR FIELD COILS

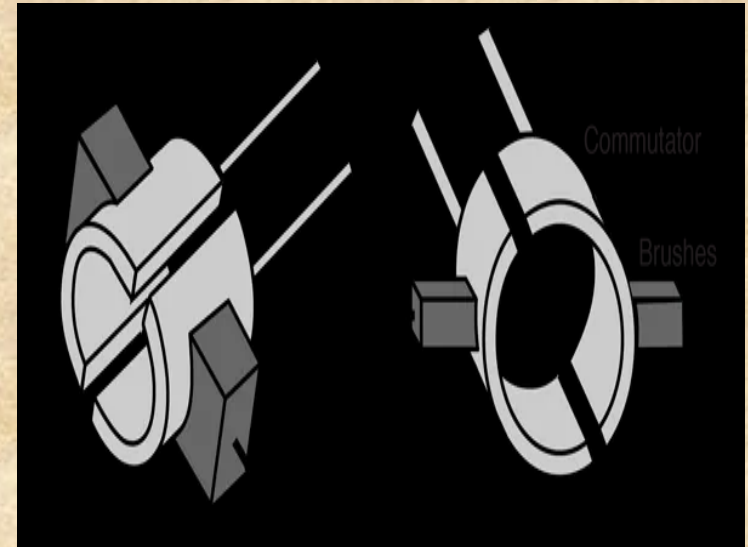


ARMATURE CORE

Construction of DC Machine

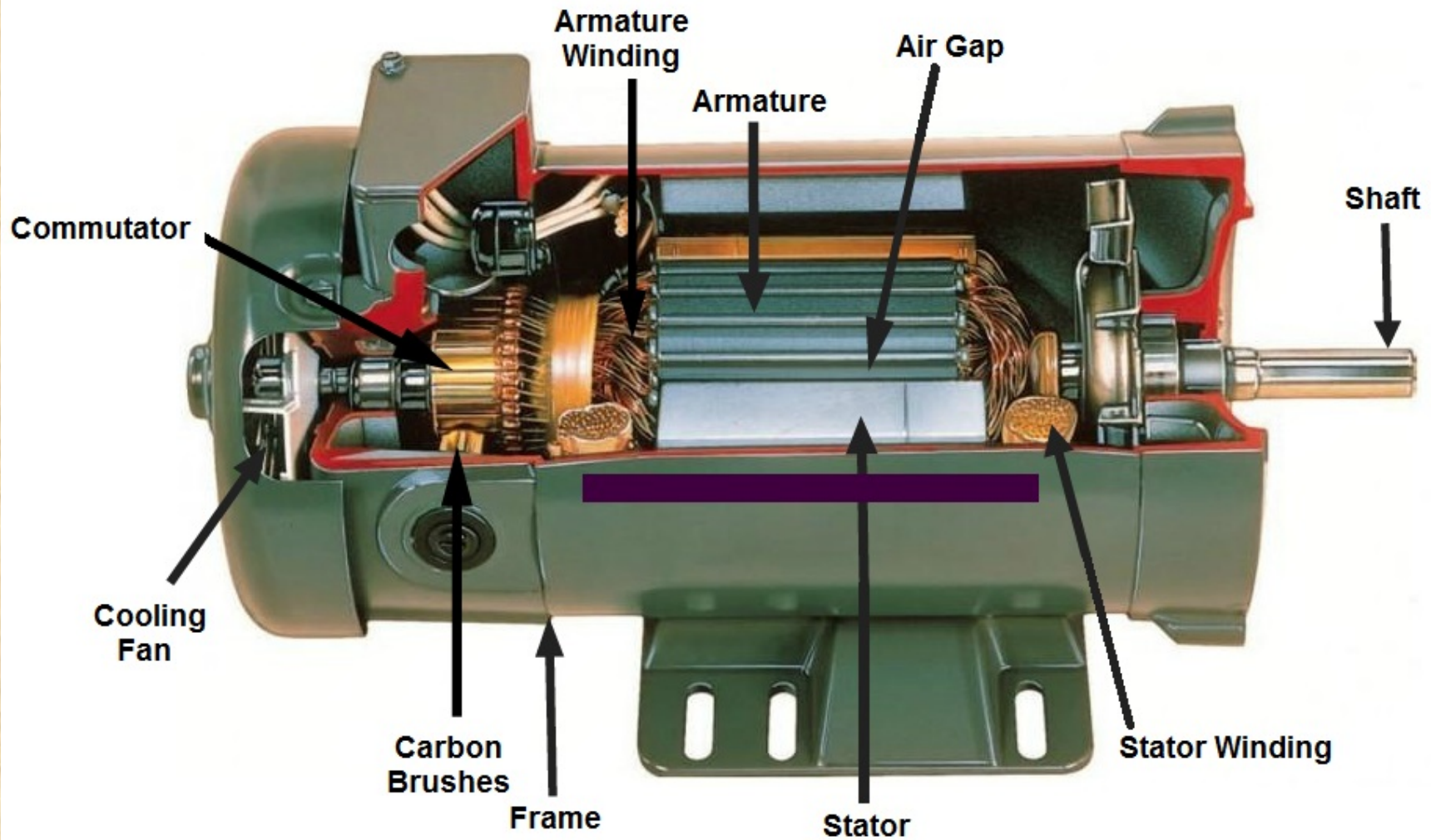


Armature winding

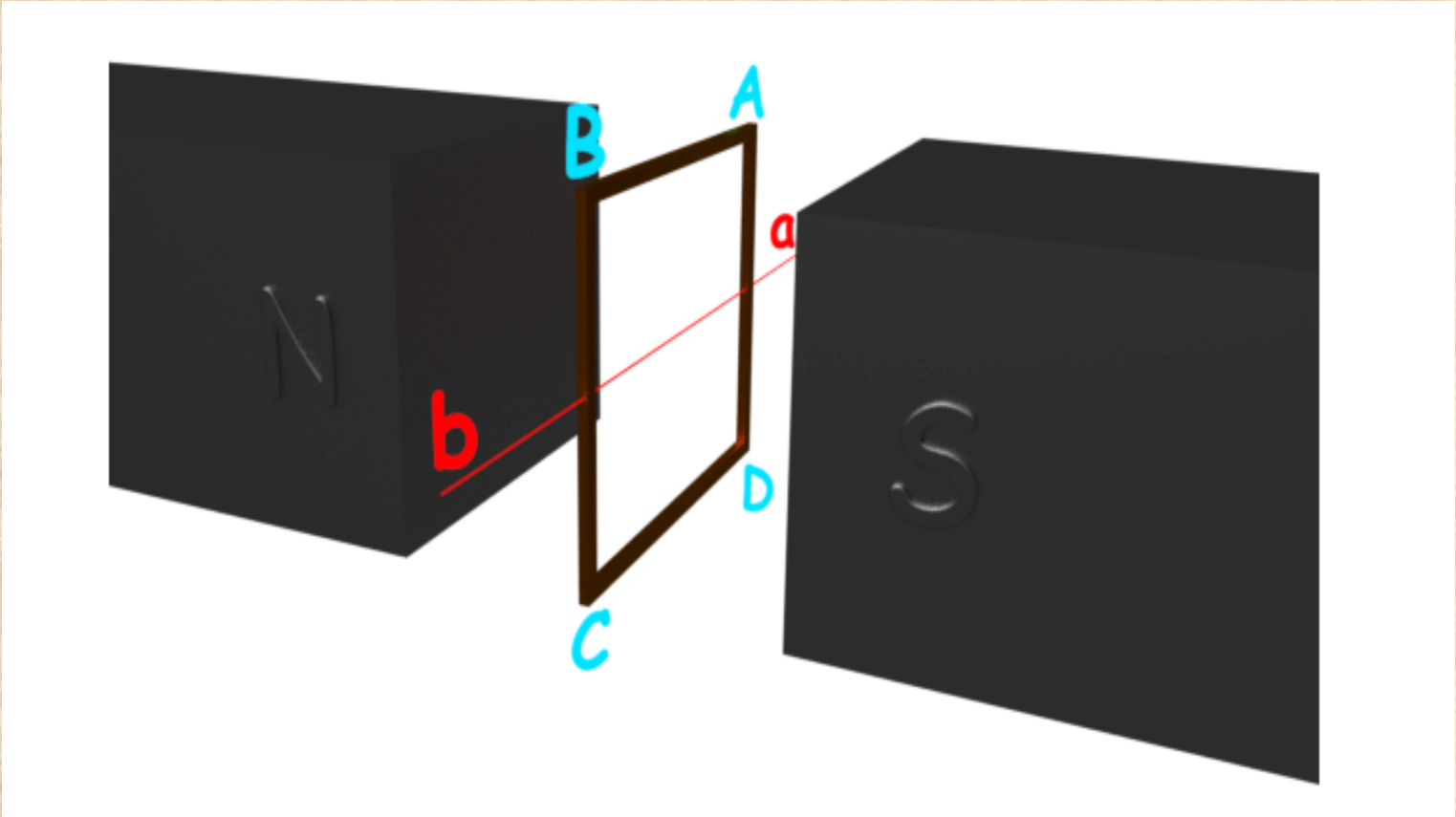


ARMATURE CORE

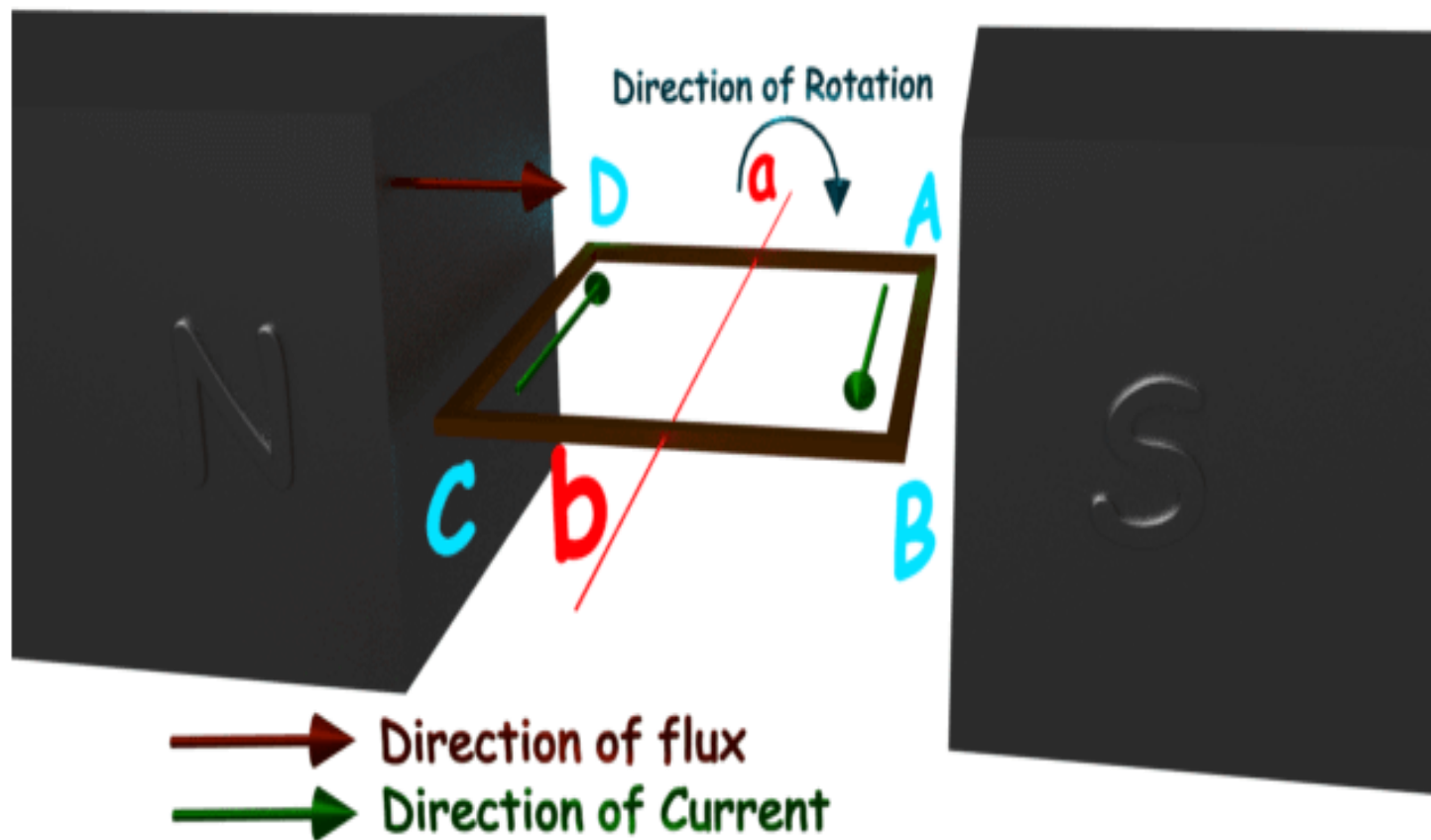
Construction of DC Machine



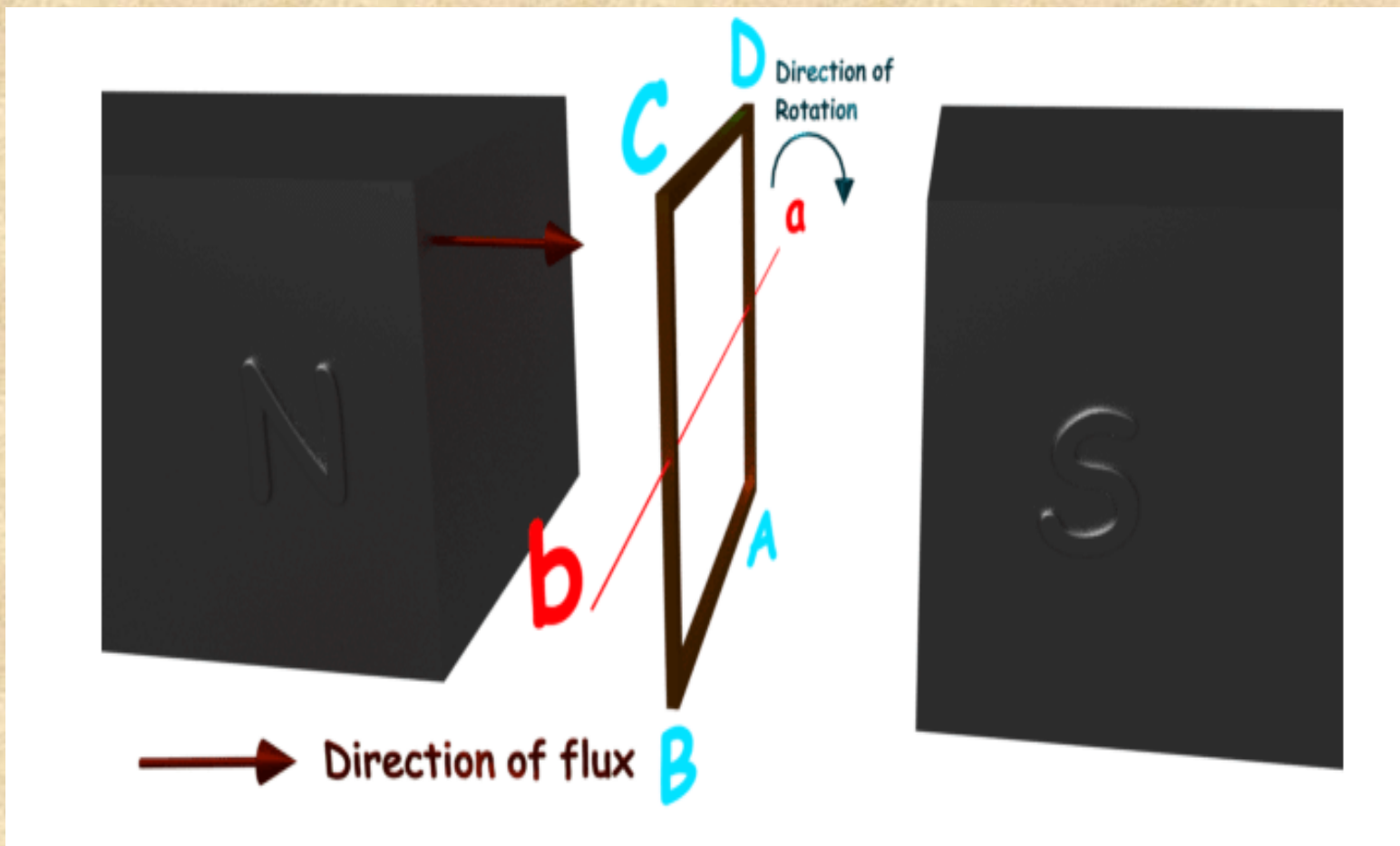
WORKING OF DC GENERATOR



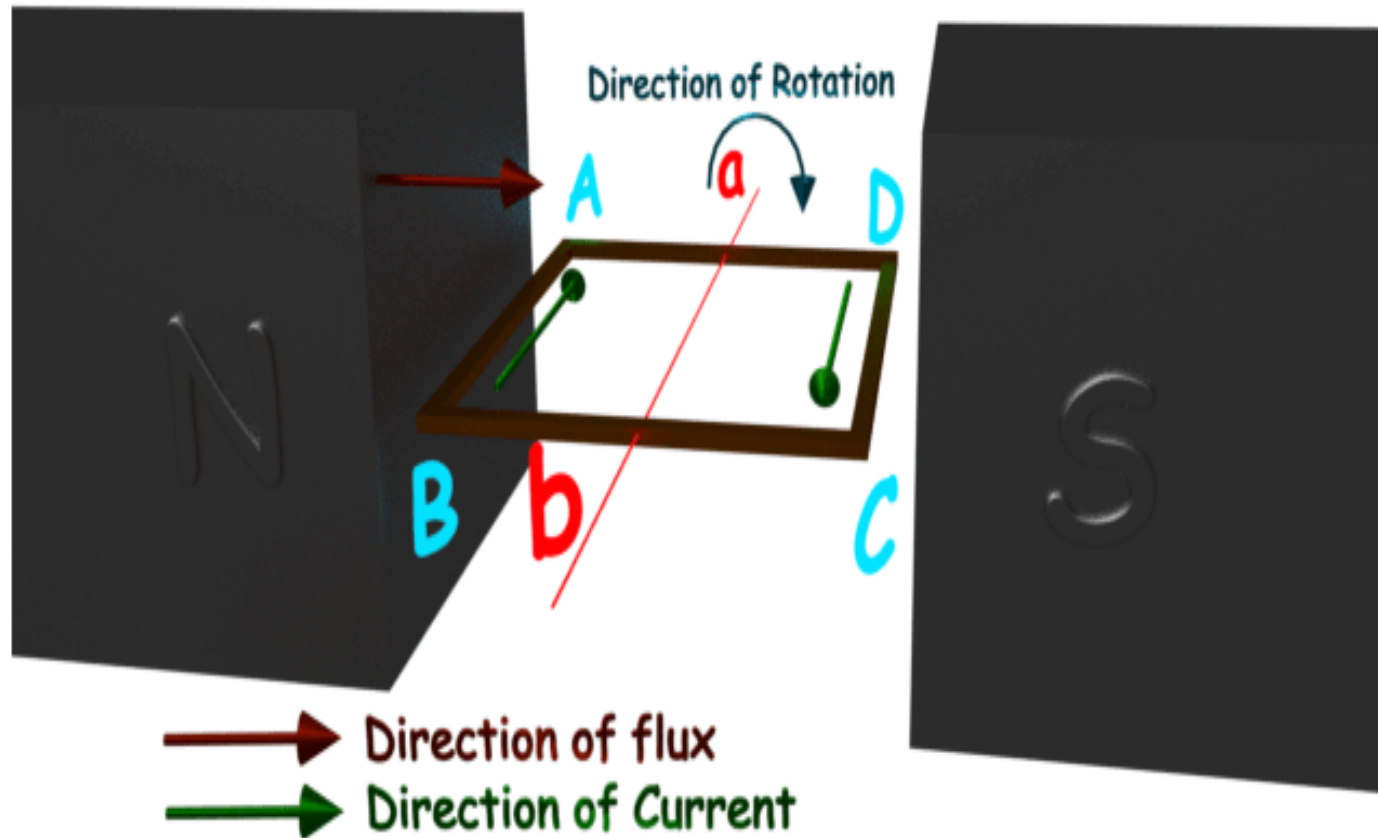
WORKING OF DC GENERATOR



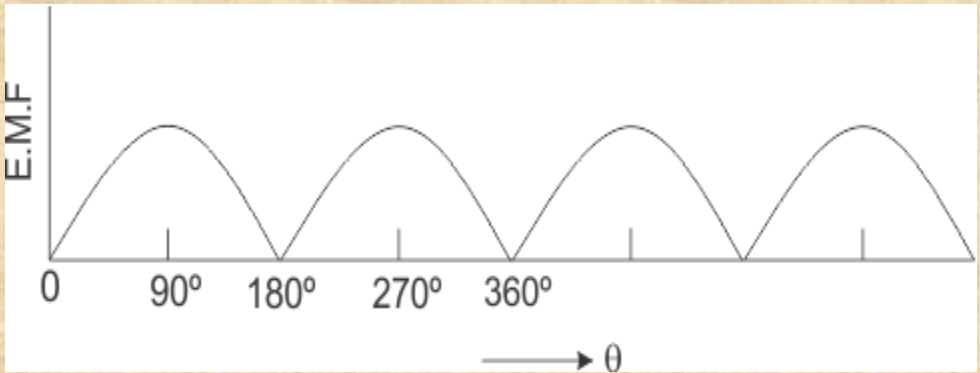
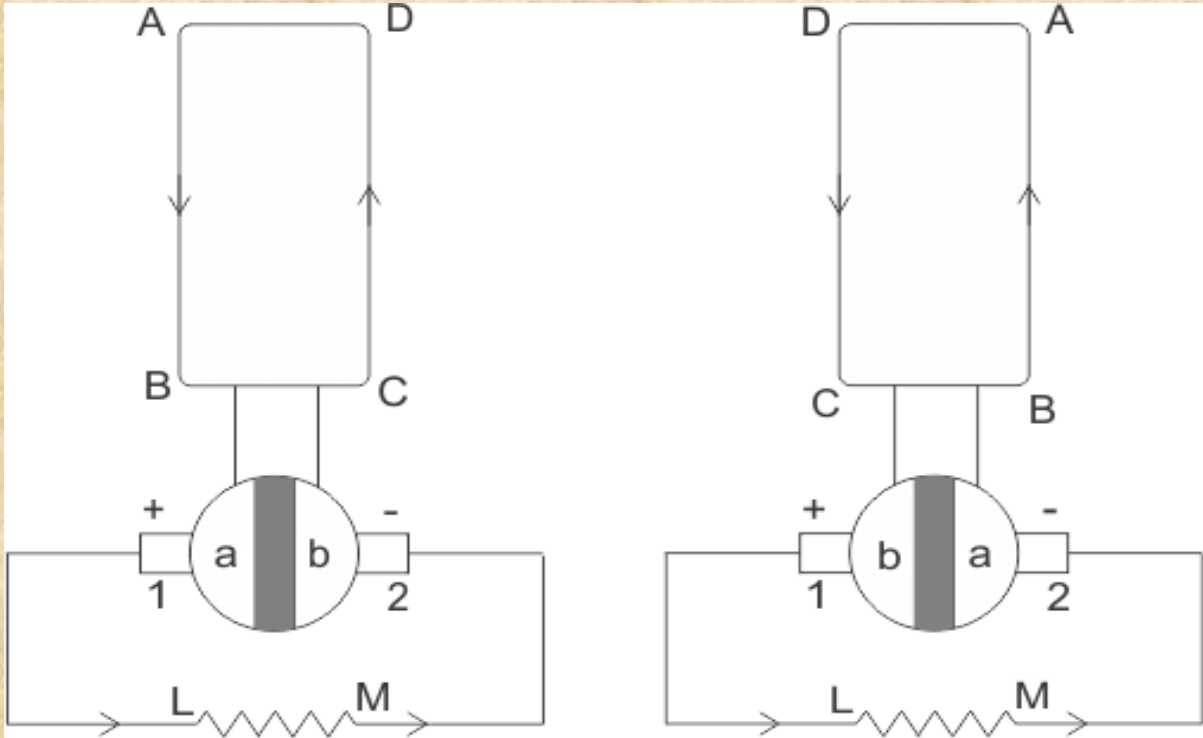
WORKING OF DC GENERATOR



WORKING OF DC GENERATOR



WORKING OF DC GENERATOR



EMF Equation of a DC Generator

P = Number of poles of the machine.

ϕ = Flux per pole in Weber.

N = Speed of Armature in Revolutions per Minute (RPM).

Z = Total number of Armature conductors.

A = Number of Parallel paths in the Armature winding.

According to Faradays Law,

$$e = \frac{d\phi}{dt} \quad \text{Volts}$$

$$e = \frac{\text{Total Flux cut}}{\text{Time required}} \quad \text{Volts}$$

In one Revolution of the armature,
the total flux cut by one conductor will be

$$e = P \phi \quad \text{Webar(eq.1)}$$

RPM = Revolutions per Minute = N

RPS = Revolutions per Second = $N / 60$

Seconds for one Revolution = $60 / N$ (eq.2)



EMF Equation of a DC Generatorcontd.

According to Faradays Law,

$$e = \frac{\text{Total Flux cut}}{\text{Time required}} \quad \text{Volts}$$

Substituting from eq.1) and eq.2) we get,

$$e \text{ per conductor} = \frac{\text{Total Flux cut}}{\text{Time required}} = \frac{P \phi}{60 / N} = \frac{P \phi N}{60} \quad \text{Volts}$$

There are total Z conductors, but all of them are not in series !

They are equally divided in A parallel paths (groups).

Thus Z/A conductors are in series. Thus,

$$\text{Total } E = \frac{P \phi N}{60} \times \frac{Z}{A} = \frac{P \phi N Z}{60 A} \quad \text{Volts}$$

This is called as the EMF Equation of a DC Generator.

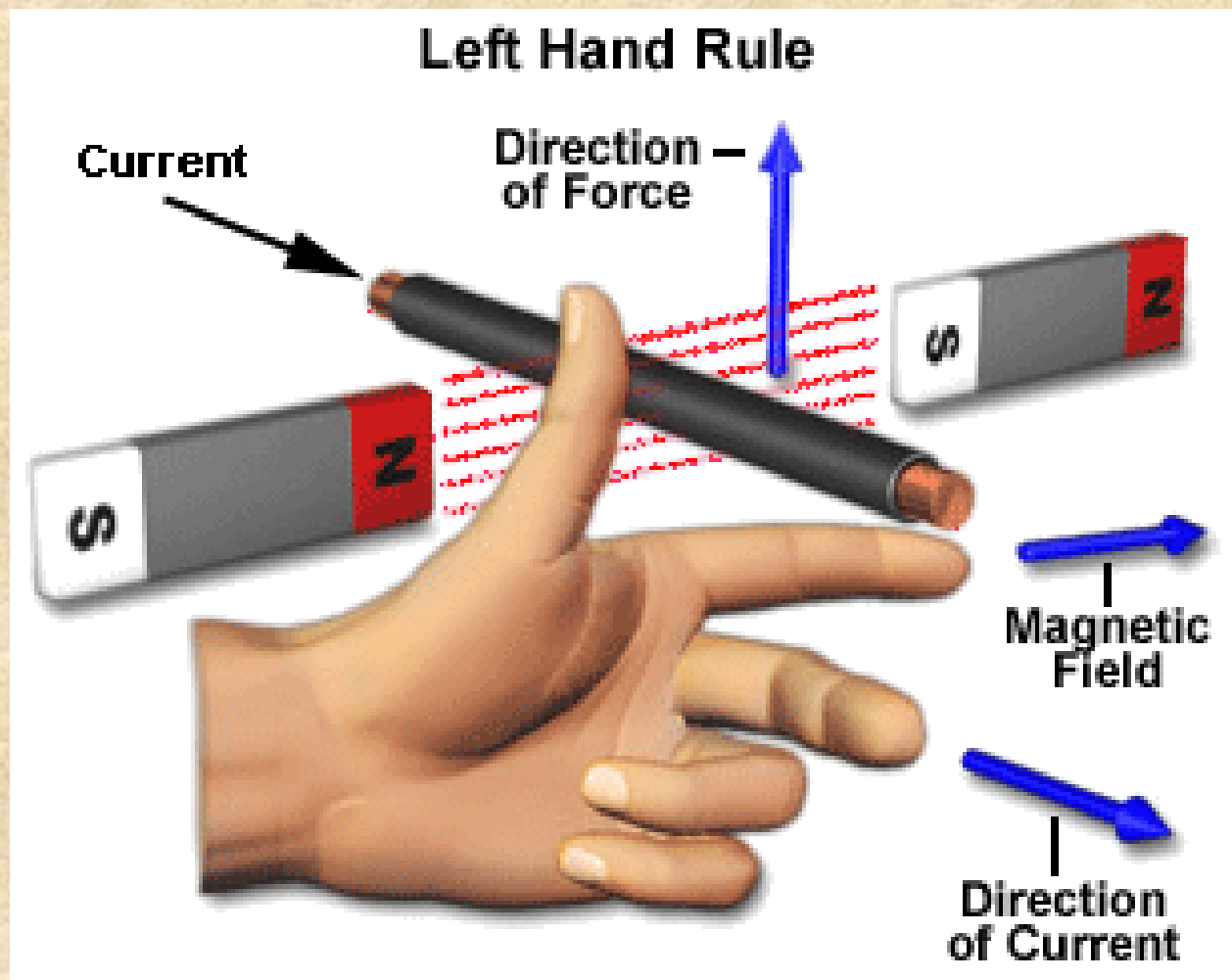
$E \propto ??$



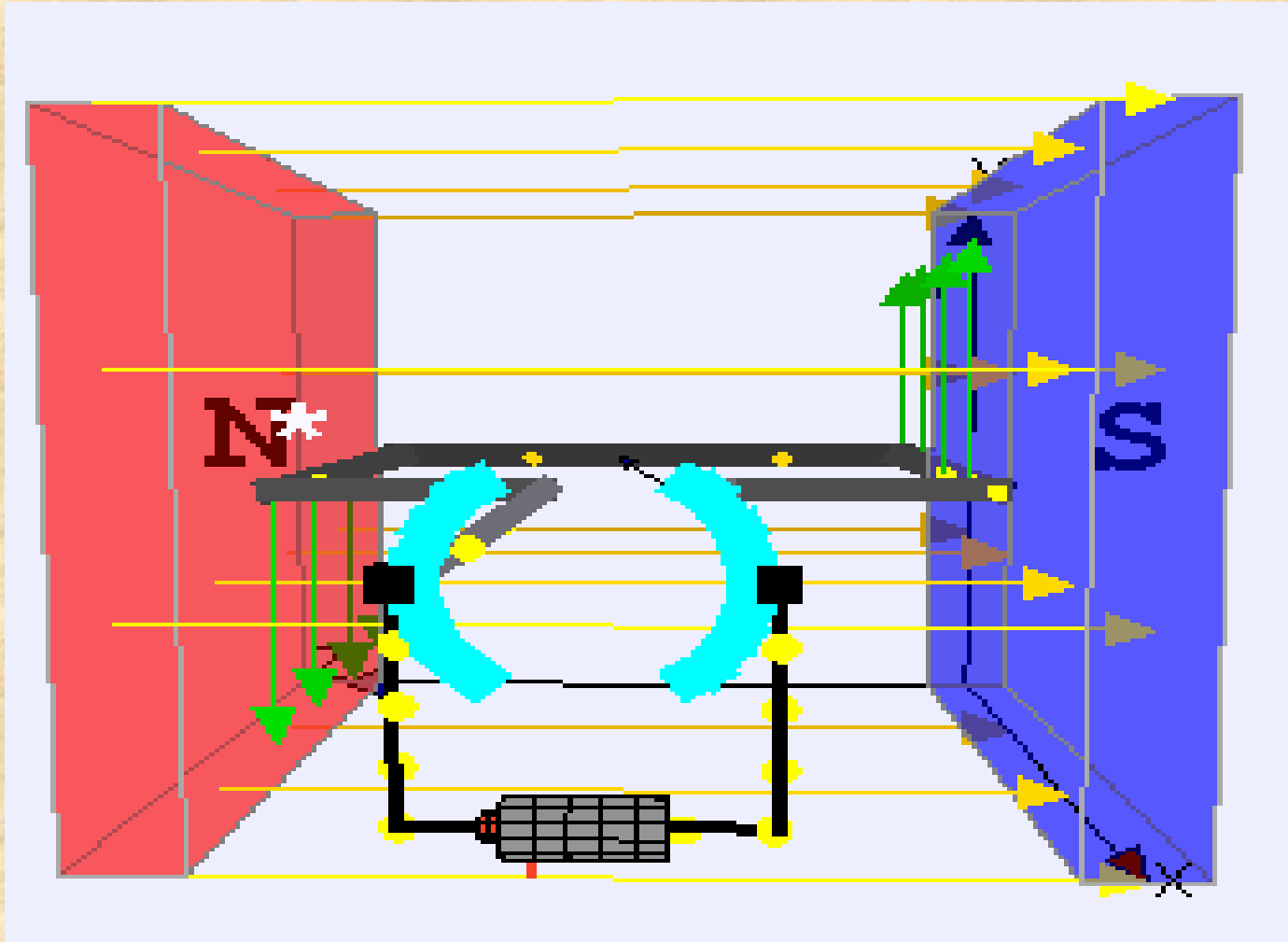
$E \propto \phi N$

All other parameters are constant...

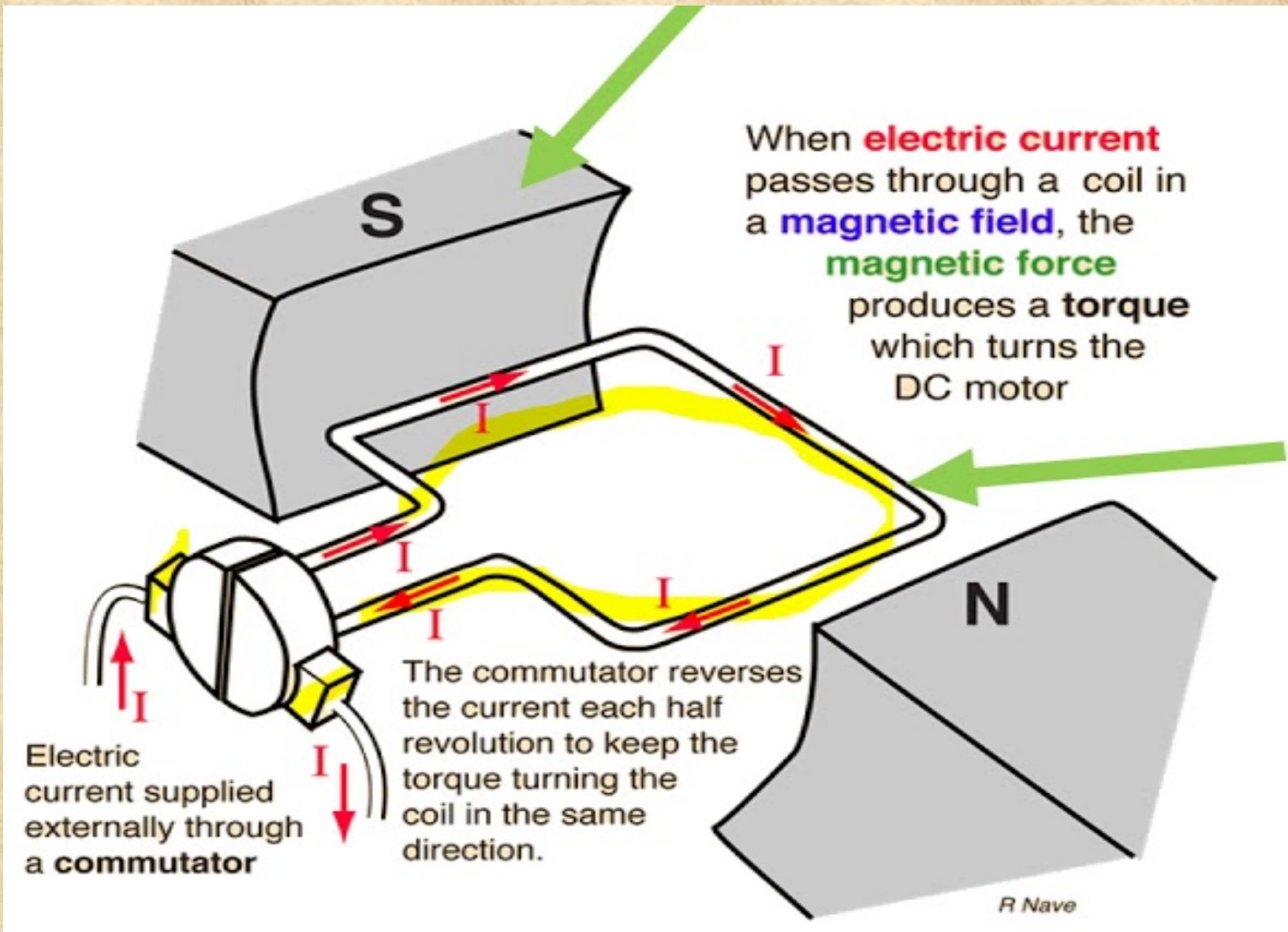
Left hand rule – Motoring action



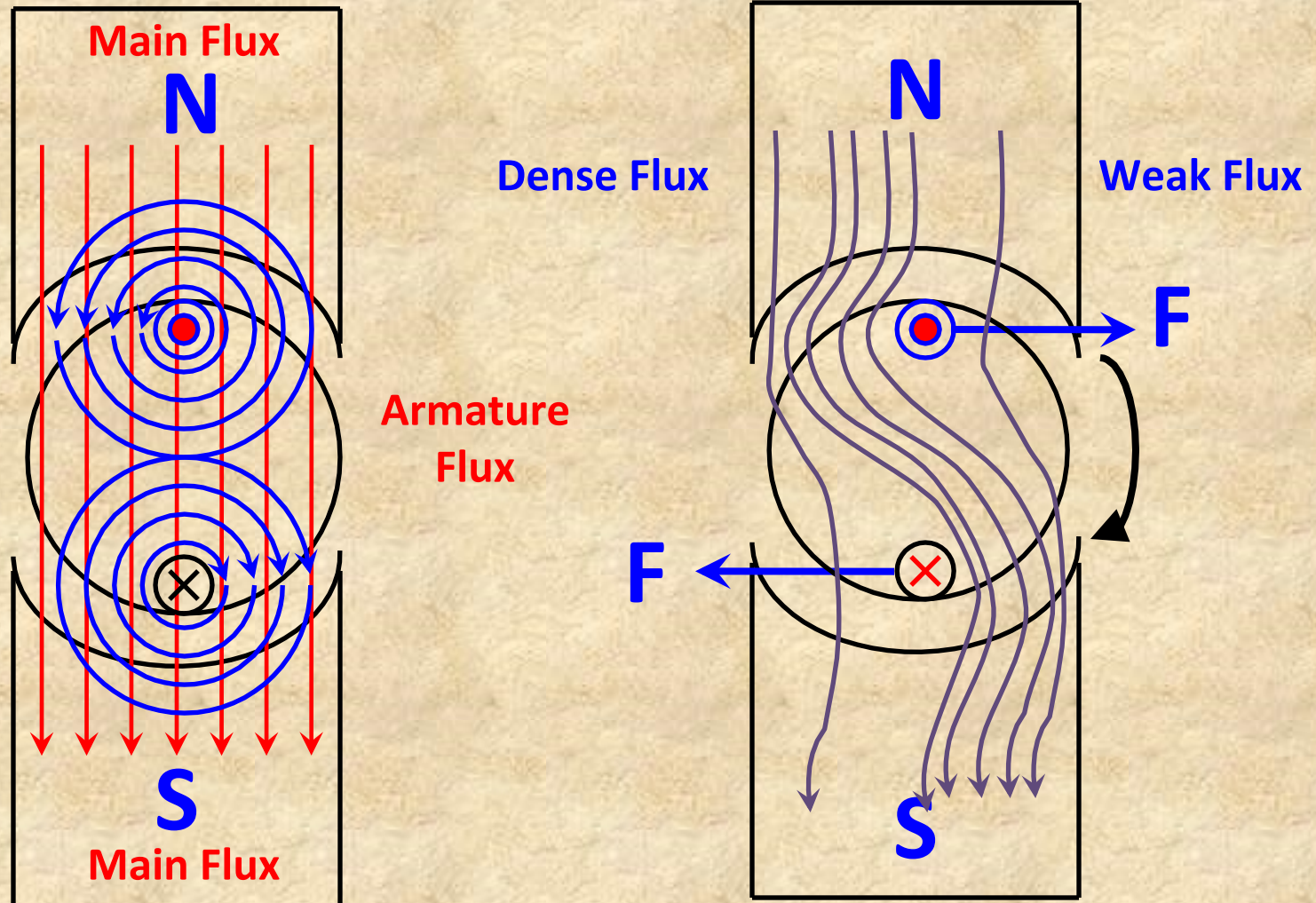
Motoring action



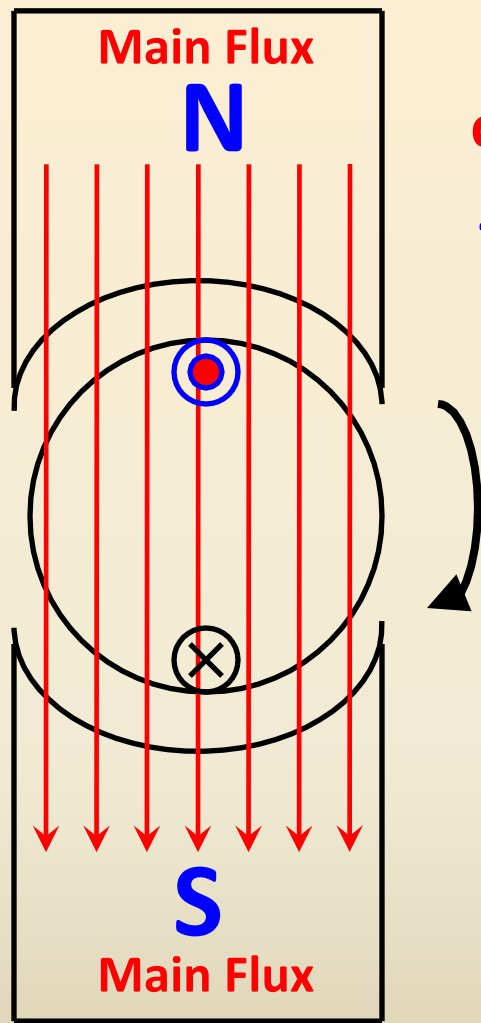
Motoring action



Motoring Action – How a DC motor works ?



Concept of Back EMF



When a motor starts rotating, the conductors cut the main flux in the air gap.

This cutting of Flux gives rise to an EMF in the conductors. (Generating action)

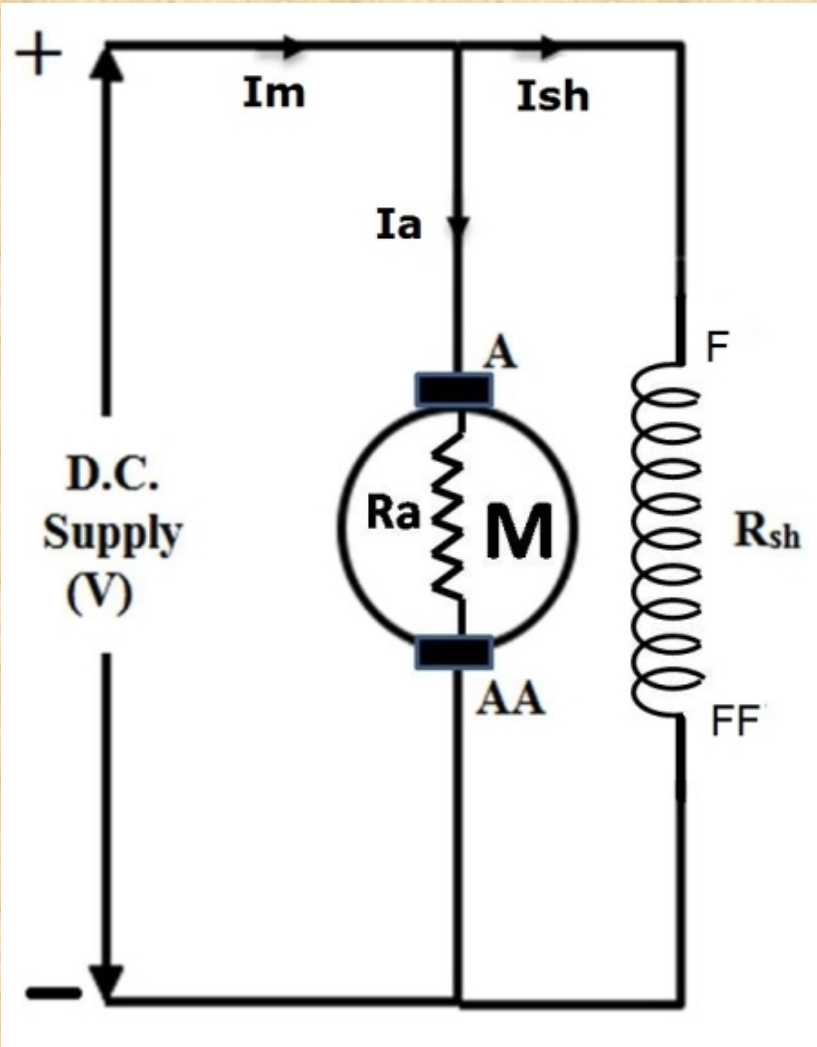
This EMF should oppose the cause producing it. (Lenz's Law)

This EMF opposes the cause i.e. the supply voltage V .

Therefore this EMF is called as Back EMF (E_b) or Counter EMF.

It should be remembered that V is supply voltage and E_b is generated EMF.

DC Shunt Motor



$$I_m - I_{sh} = I_a$$

$$V - I_a R_a = E_b$$

Some typical practical values of different parameters of a DC shunt motor are

- $V = 230 \text{ V DC}$
- $I_m = 10 \text{ A}$ (depends upon HP)
- $I_a = 9 \text{ Amp}$
- $I_{sh} = 1 \text{ Amp}$
- $R_a < 1.0 \text{ ohm}$
- $R_{sh} = 200+ \text{ ohm}$
- V drops at brushes also.
- $E_b = 227 \sim 228 \text{ V}$

$$E_b = V - I_a R_a \text{ Multiply both sides by } I_a$$

$$E_b I_a = V I_a - I_a^2 R_a \text{(1)}$$

This is a power equation now...

$$E_b I_a = \text{Input} - \text{Loss (Heat generated)}$$

$$\text{Thus..... } E_b I_a = \text{Output (IMP parameter)}$$

$$\text{But } E_b = \frac{P \phi N Z}{60 A} \text{ Substitute in (1)}$$

$$P \phi N Z$$

$$E_b = \frac{\text{-----}}{60 A} \times I_a = T \times \omega \text{ ...(Elect to Mech)}$$

$$\text{But } \omega = 2\pi N / 60$$

$$\text{Thus..... } T = \frac{1}{2\pi} \times \frac{P \phi Z I_a}{A} \text{ N-m}$$

This is called as the Torque equation of DC Motor

$$T \propto \phi I_a \text{ ...(Other parameters are constant)}$$

$$E_b = \frac{P \phi N Z}{60 A} \quad (\text{basically } E_b \text{ is a generated EMF})$$

$$E_b \propto \phi N$$

$$N \propto E_b / \phi$$

$$N \propto \frac{E_b}{\phi} = \frac{V - I_a R_a}{\phi}$$

Effect of loading on the motor speed

$$N \propto \frac{V - I_a R_a}{\phi}$$

Diagram illustrating the effect of loading on motor speed. A red arrow points down next to N , indicating a decrease in speed. A red arrow points up next to I_a , indicating an increase in armature current. The equation shows that speed N is proportional to the back EMF $(V - I_a R_a)$ divided by the flux ϕ .

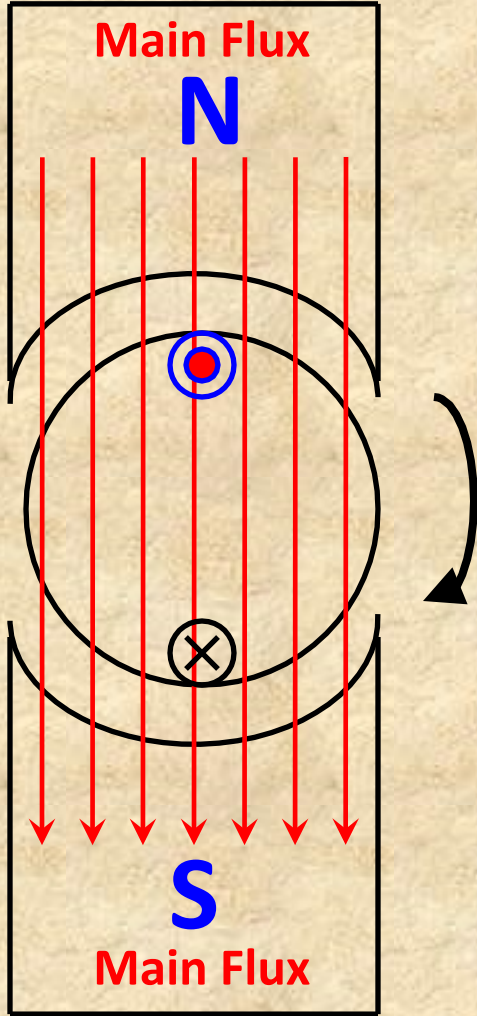
When Motor is **loaded**, it will take more current from supply and the speed has to drop because of loading.

$$N \propto \frac{V - I_a R_a}{\phi}$$

Diagram illustrating the effect of unloading on motor speed. A red arrow points up next to N , indicating an increase in speed. A red arrow points down next to I_a , indicating a decrease in armature current. The equation shows that speed N is proportional to the back EMF $(V - I_a R_a)$ divided by the flux ϕ .

When Motor is **unloaded**, it will take less current from supply and the speed has to rise.

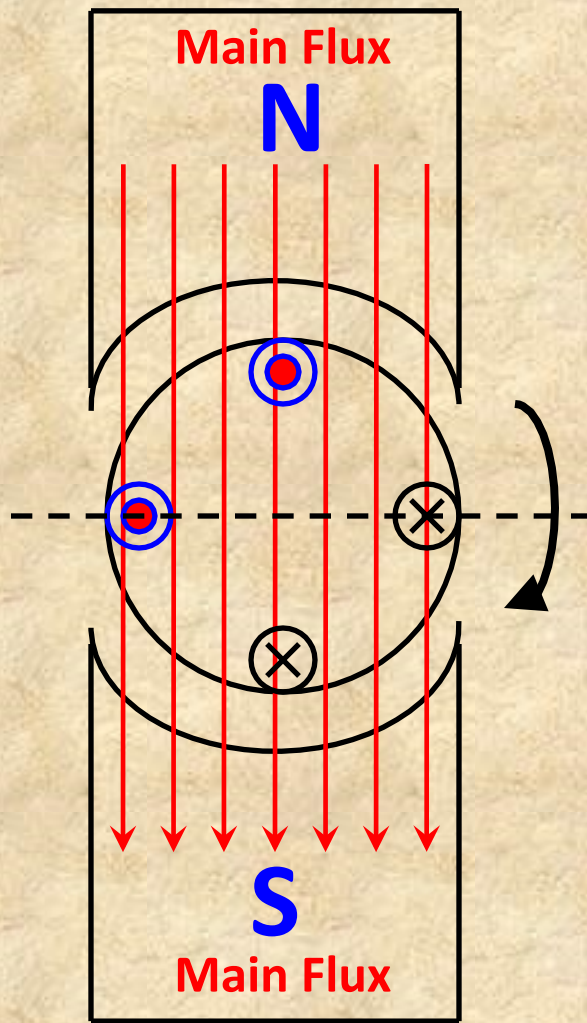
Direction of rotation of DC motor



Assume that the motor starts and goes through 180° of rotation.

So, what is the new direction ???
Same or Reversed ????

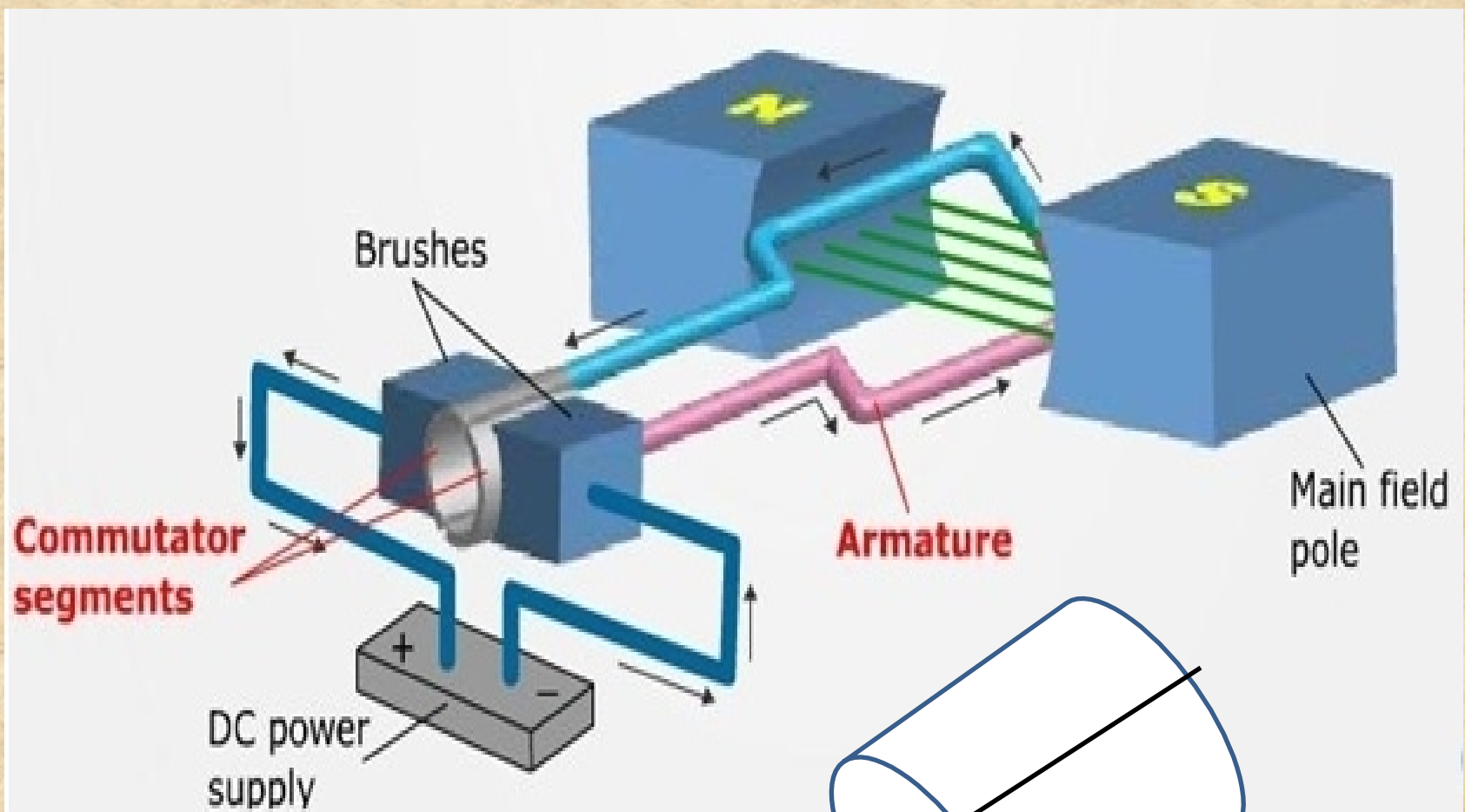
How do we get a unidirectional rotation ?



When a DOT goes from N to S, it no more remains DOT when it reaches S. Rather it reverses the direction of current through itself and **becomes a CROSS**.

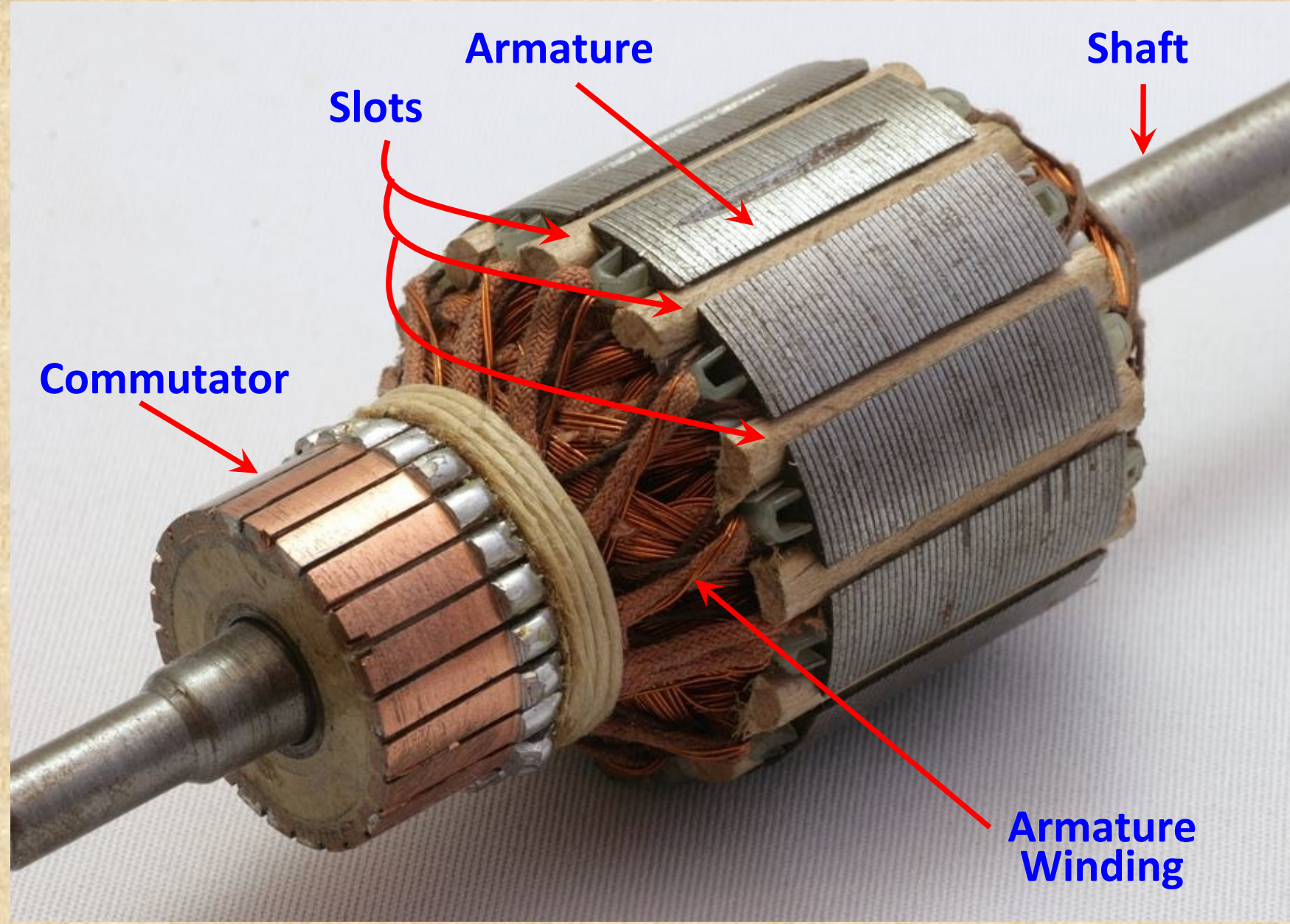
Exactly opposite thing happens in case of the CROSS under S pole.

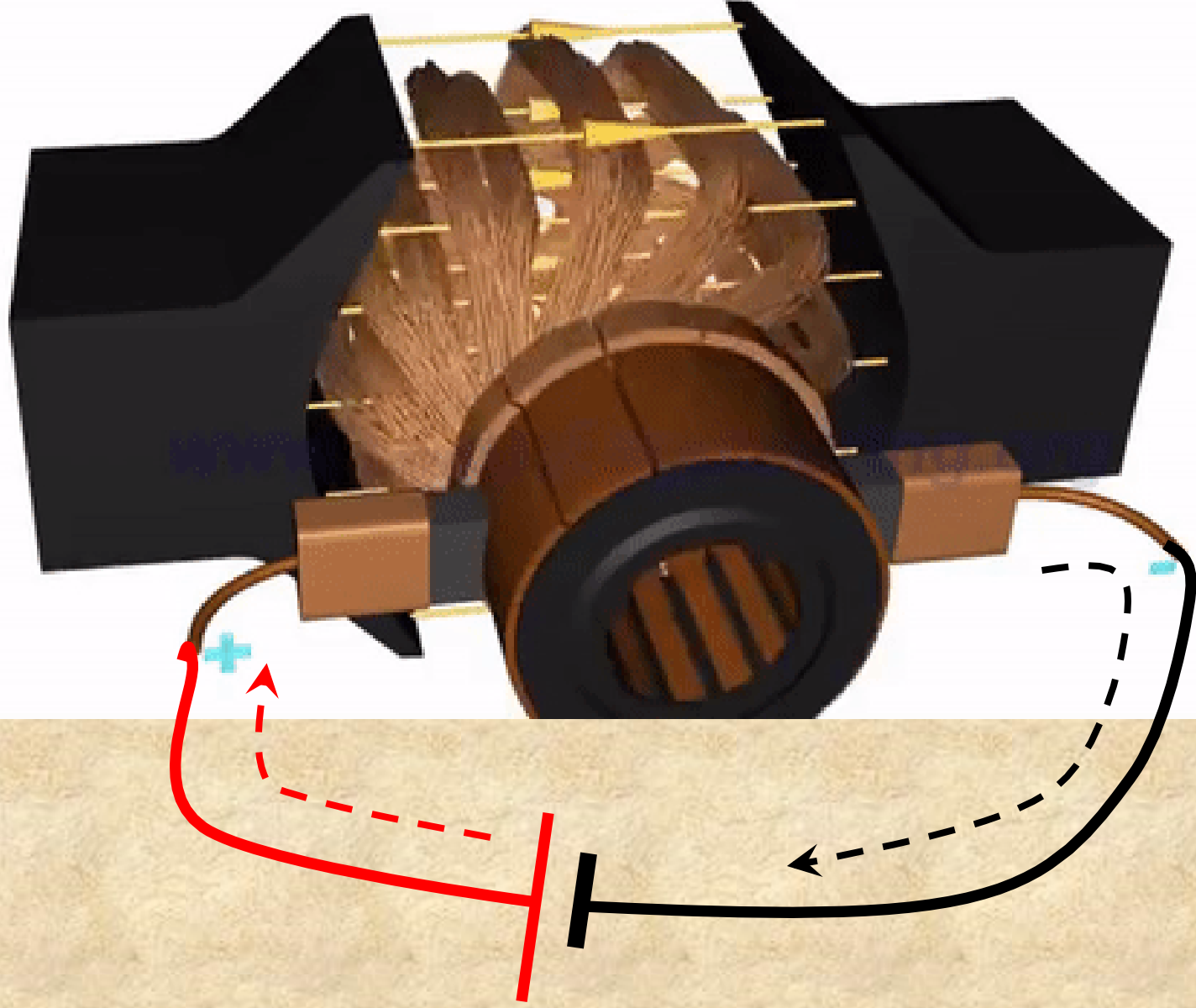
This amazing change takes place because the **COMMUTATOR !**



Commutator is divided into 2 halves called as segments.

**Practically,
no. of segments = no. of slots in the armature**





DC Motor characteristics –

$$N \propto \frac{E_b}{\phi} = \frac{V - I_a R_a}{\phi}$$

$$N \propto \frac{1}{I_a}$$

$$\text{Thus..... } T = \frac{1}{2\pi} \times \frac{P \phi Z I_a}{A}$$

$$T \propto I_a$$

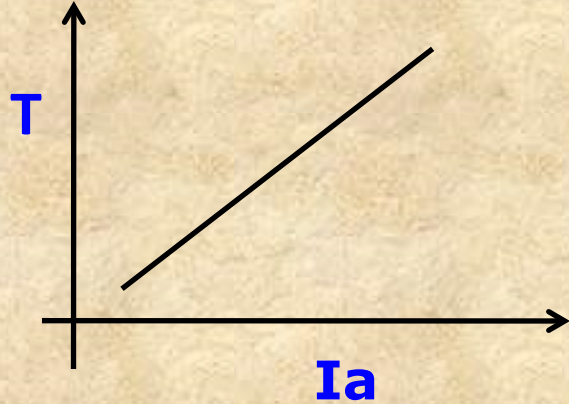
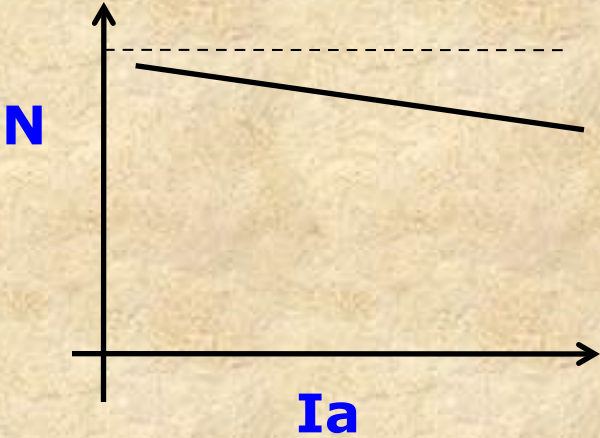
Characteristics are graphical relations between I_a , T and N

DC Motor characteristics –

$$N \propto \frac{1}{I_a}$$

$$T \propto I_a$$

Draw a graph for the relation between T and N.



F

N

Actuators – 3.3 DC Brush Motors Thanks !

FY – DESH – VIT



DC Motor



AC Motor

