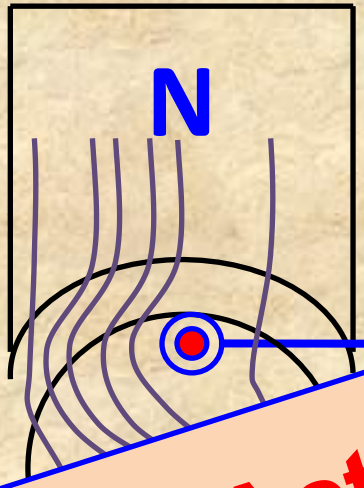
Vishwakarma Institute of Technology

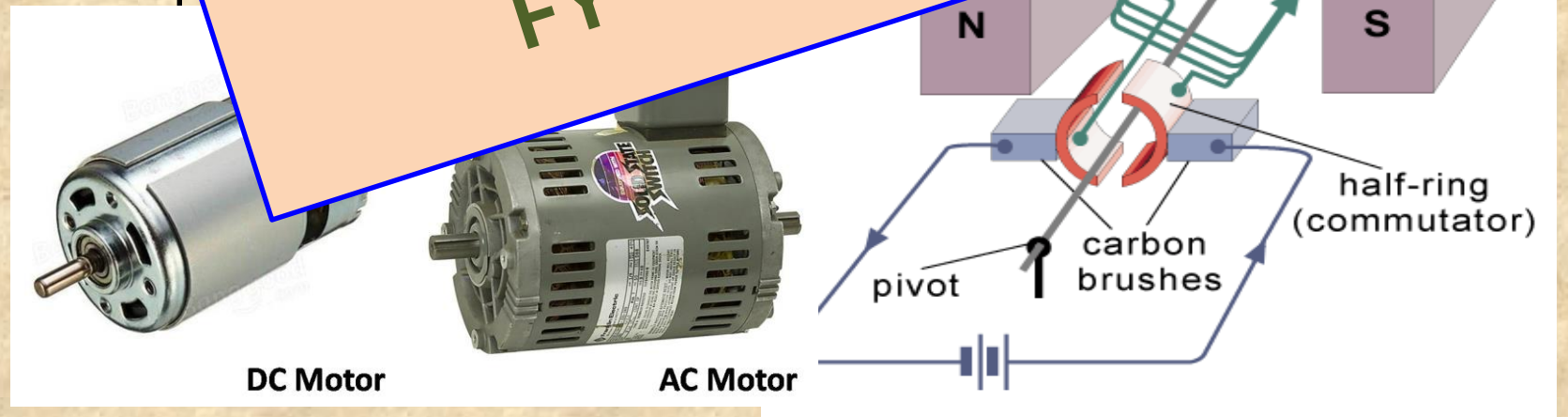
FY - Department of Engineering, Sciences and Humanities



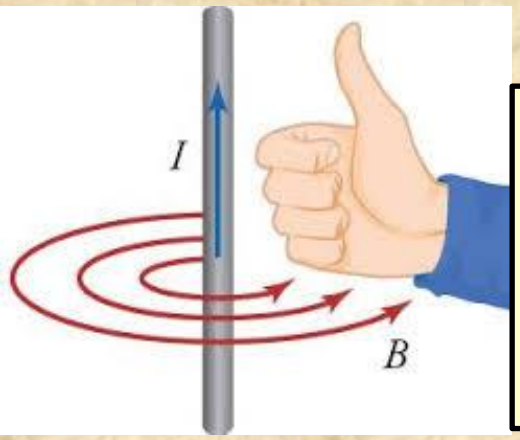
Actuators – 3.3

DC Brush Motors

FY – DESH – VIT

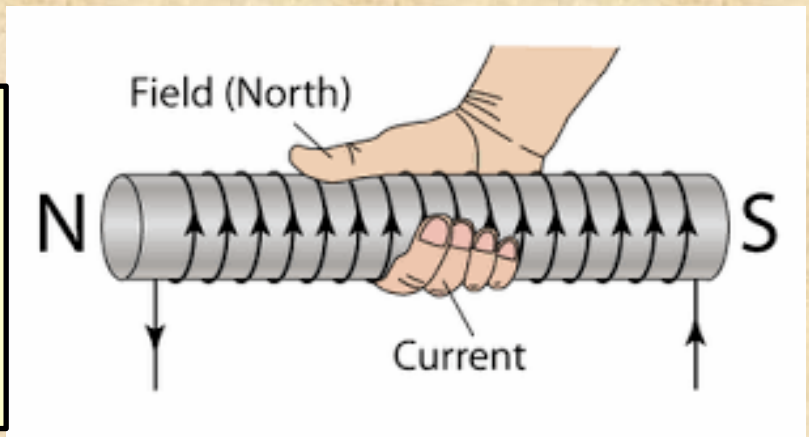


1) Right hand thumb rule – Relation between Magnetism and Current

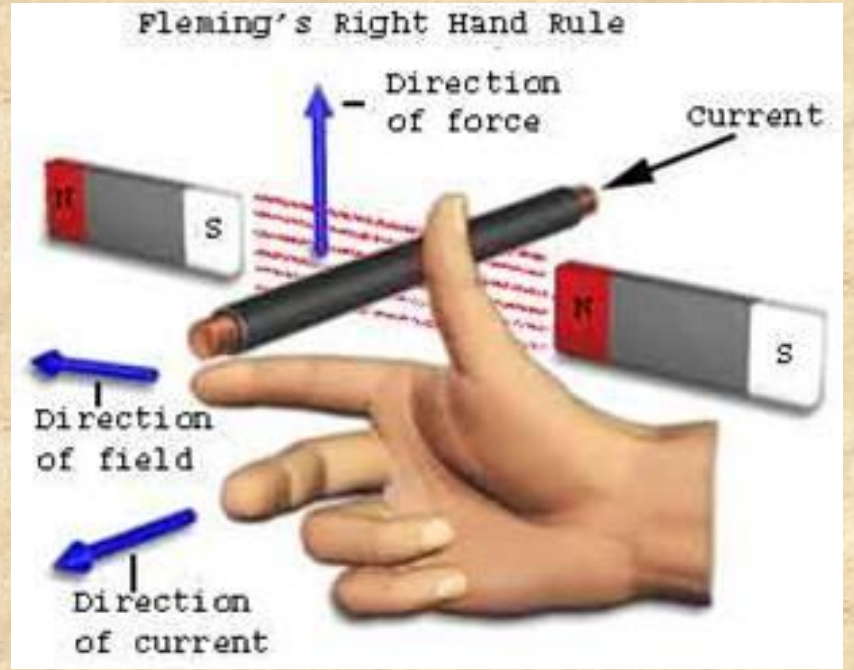


Thumb is for Current OR Flux ?

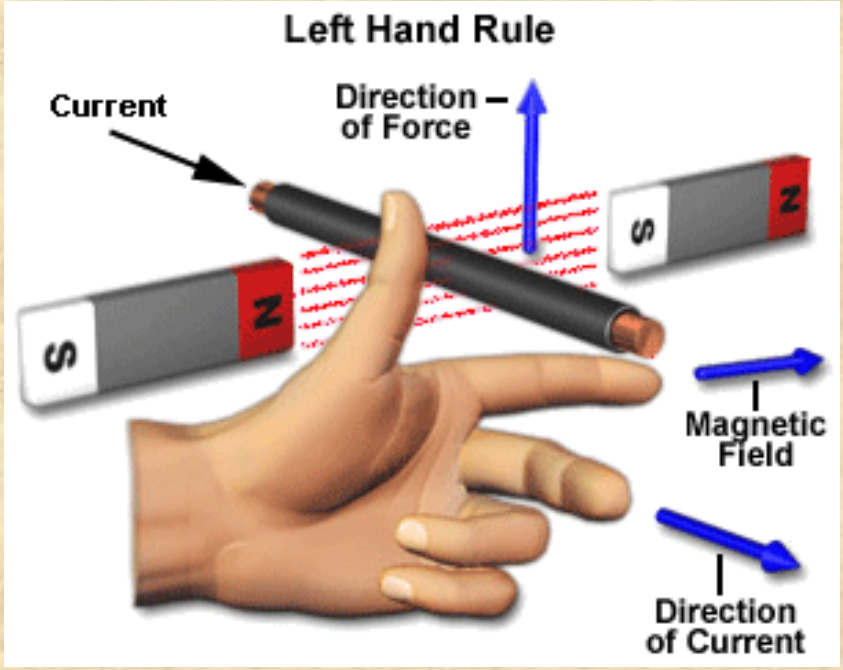
Which figure is correct ?

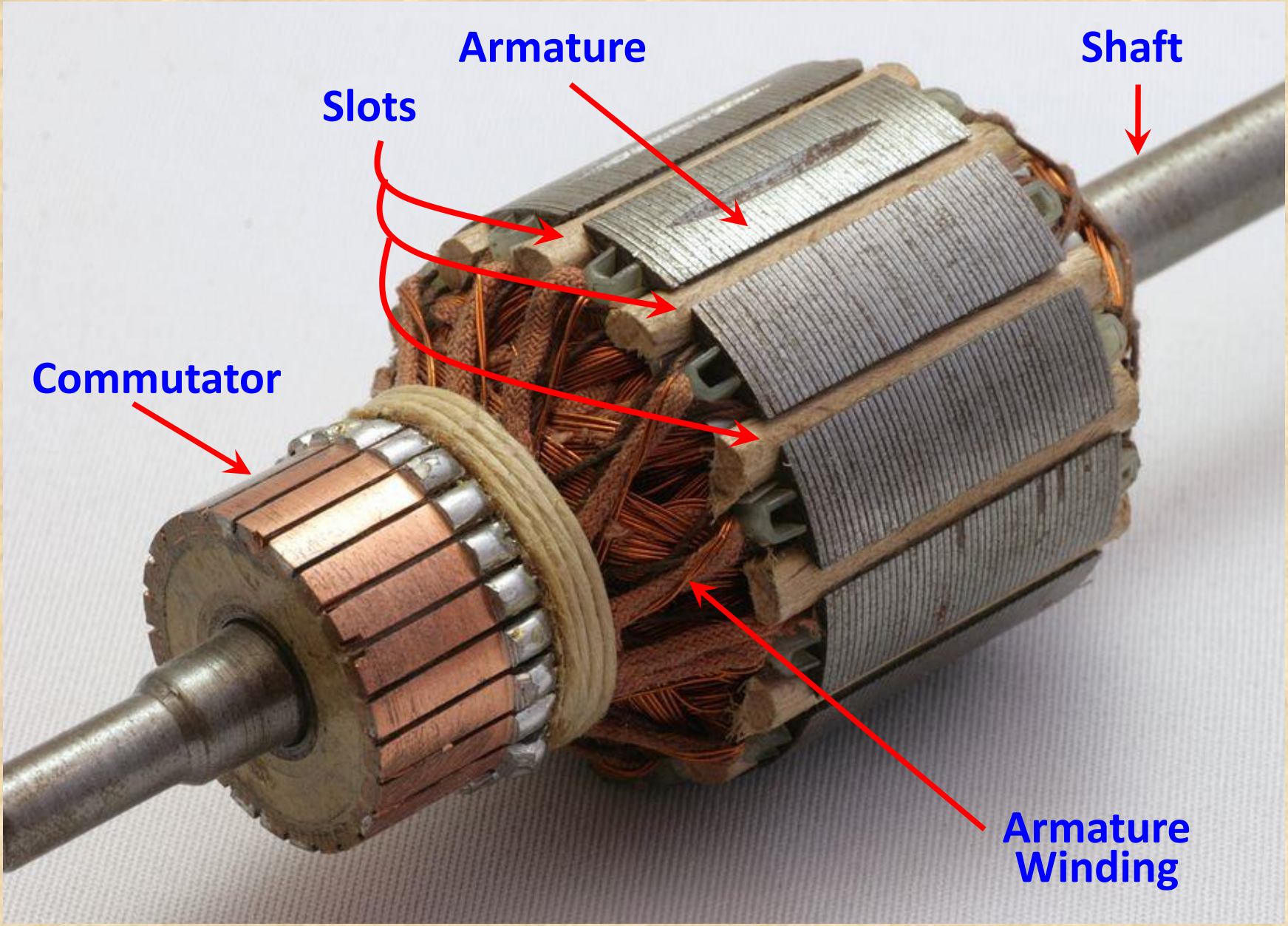


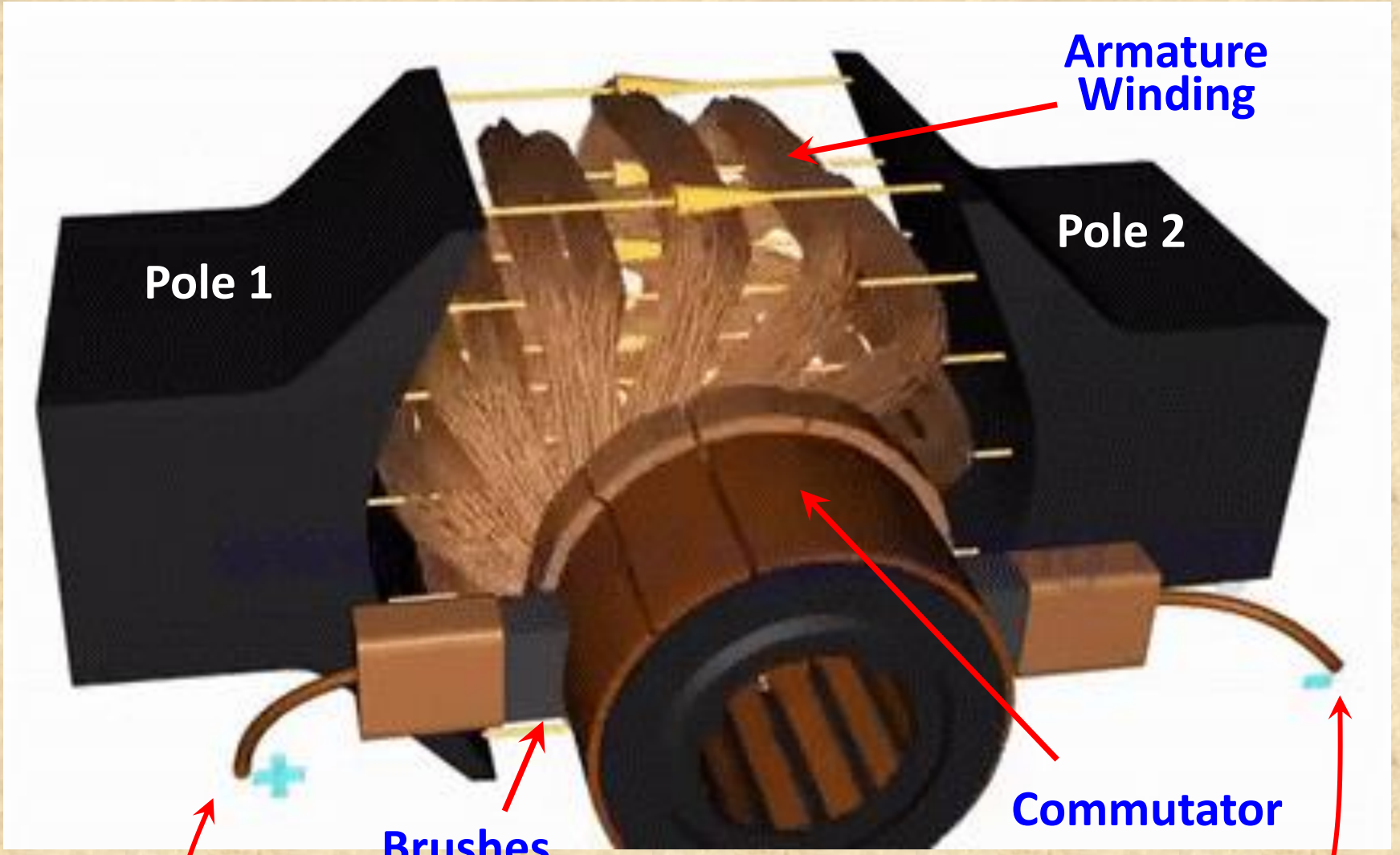
2) Right hand rule – Generating action

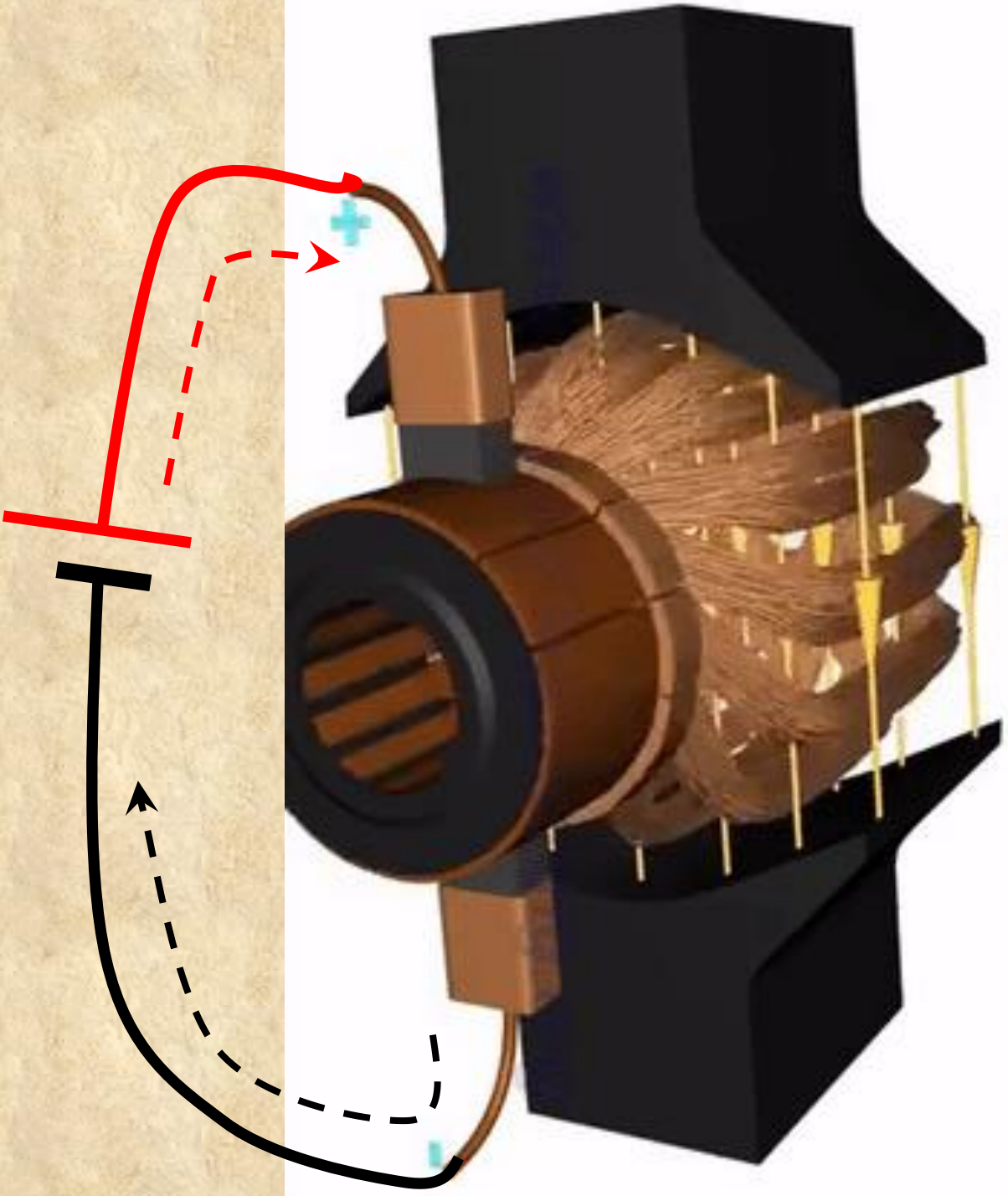


3) Left hand rule – Motoring action

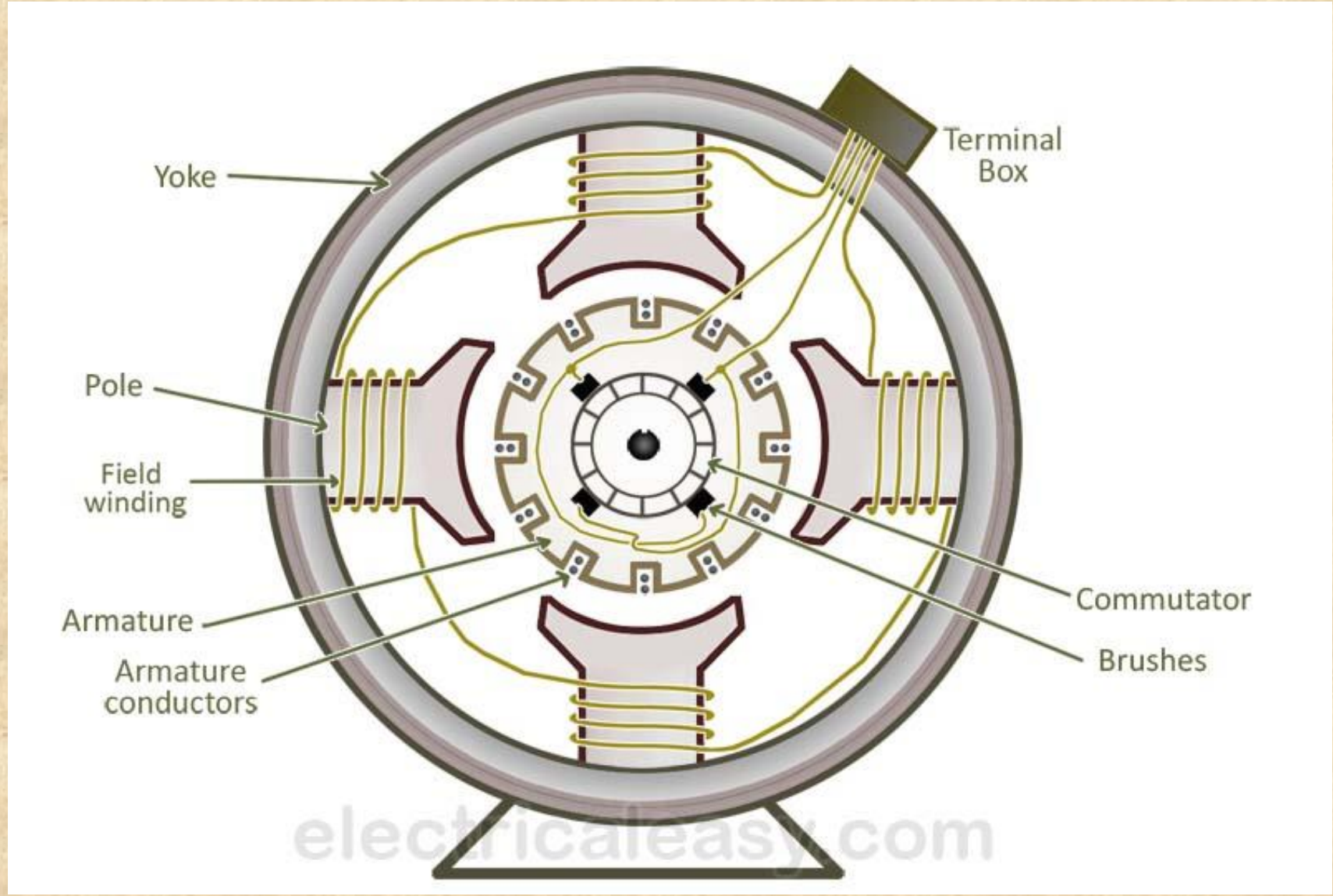



Armature
Shaft
Slots
Commutator
Armature
Winding

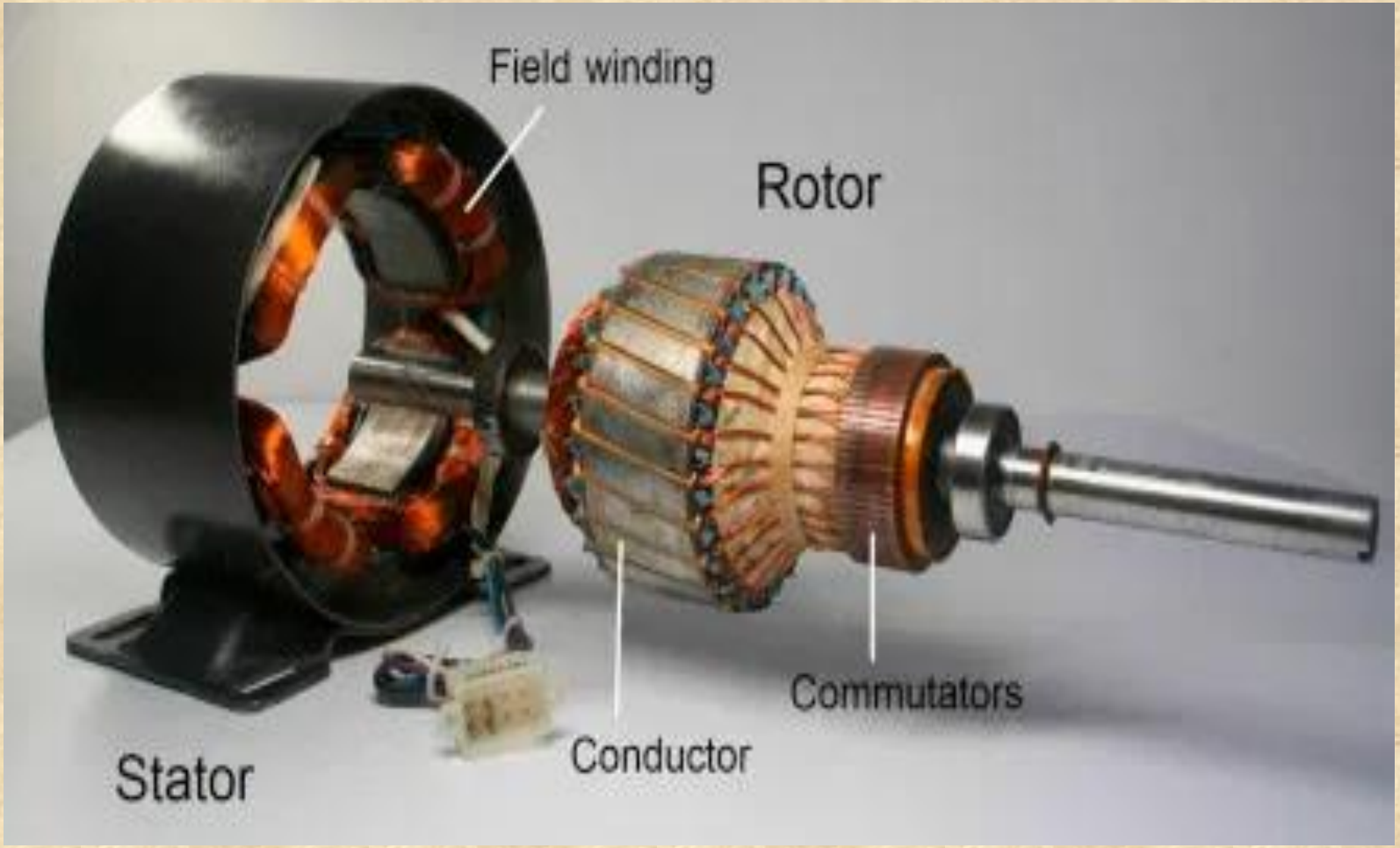

Armature Winding
Pole 1
Pole 2
Brushes
Commutator
+ External DC supply connections −



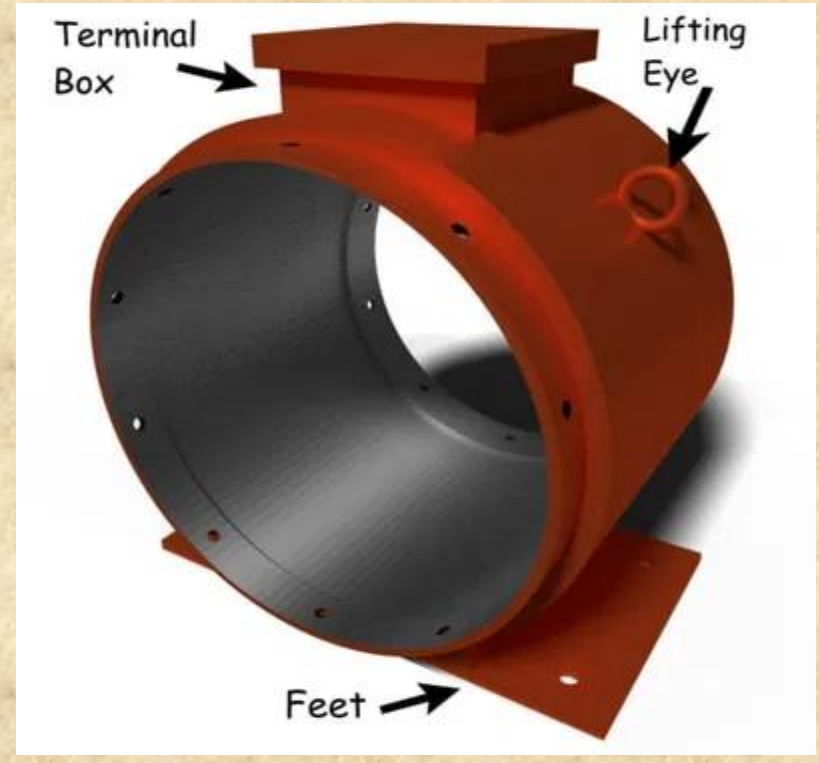
Construction of DC Machine



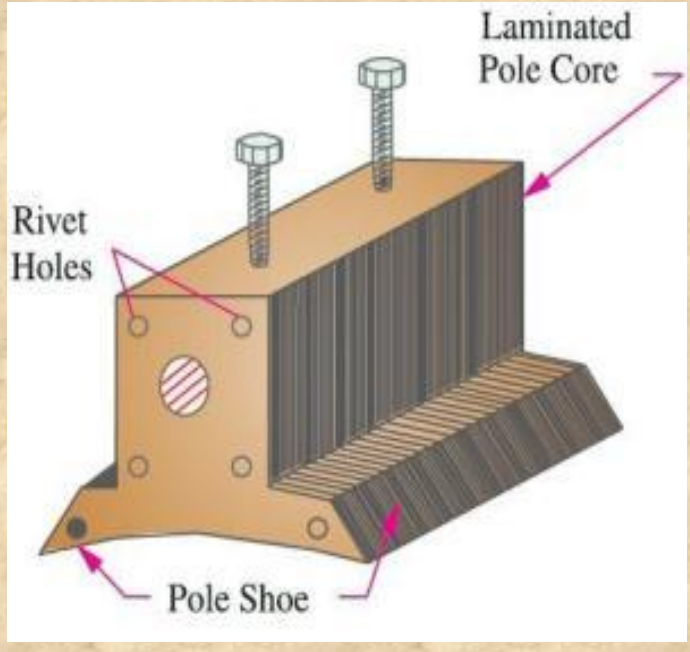
Construction of DC Machine



Construction of DC Machine

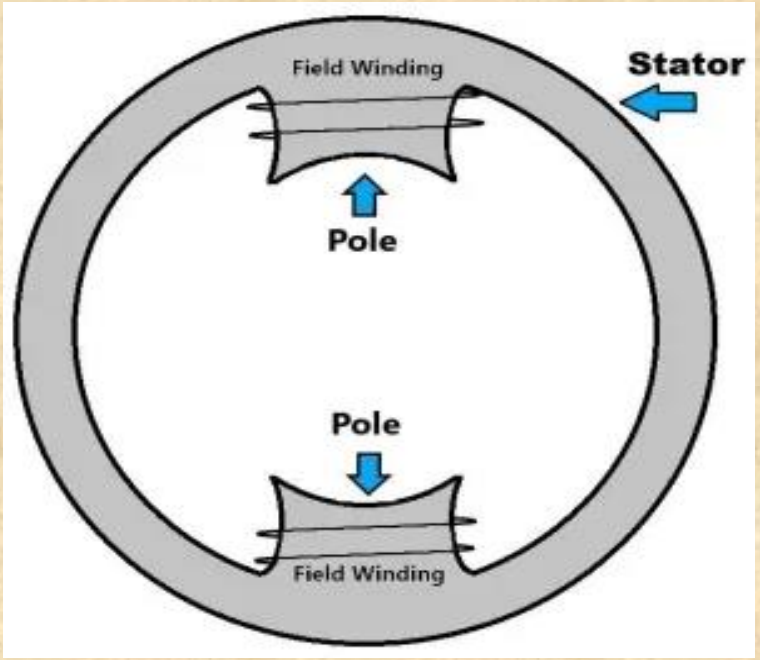


YOKE



POLE CORE AND POLE SHOE

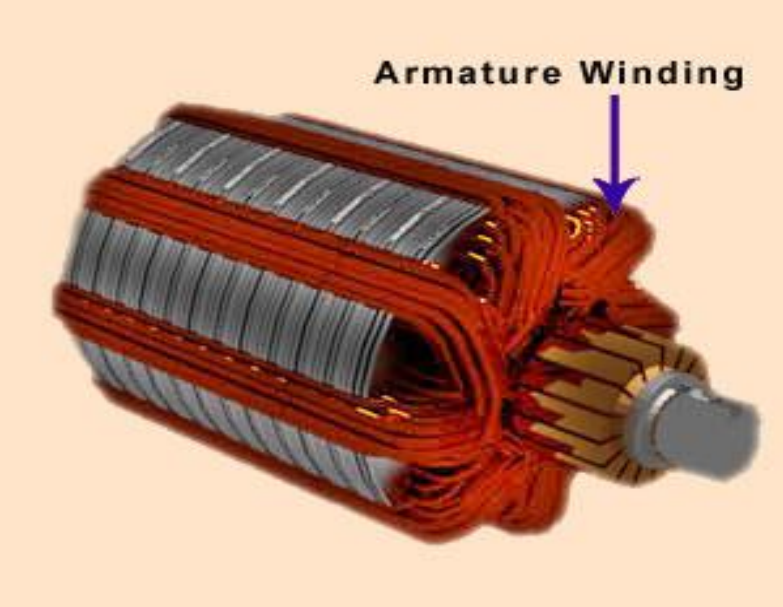
Construction of DC Machine



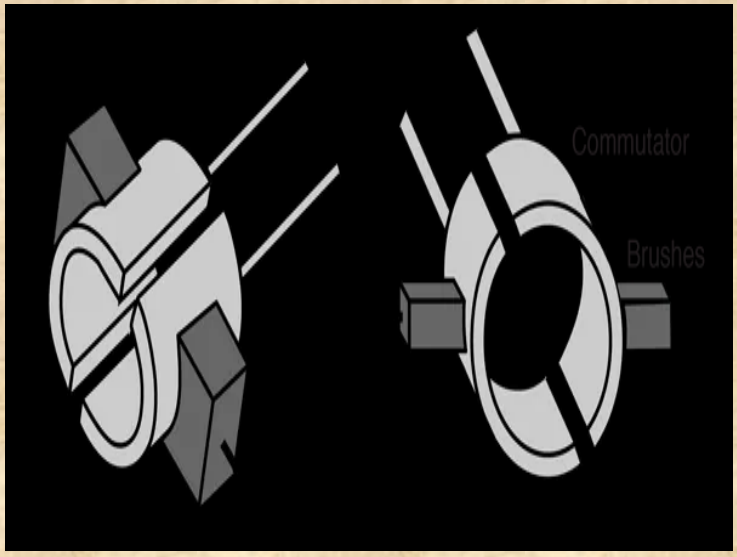
POLE WINDING OR FIELD COILS

ARMATURE CORE

Construction of DC Machine

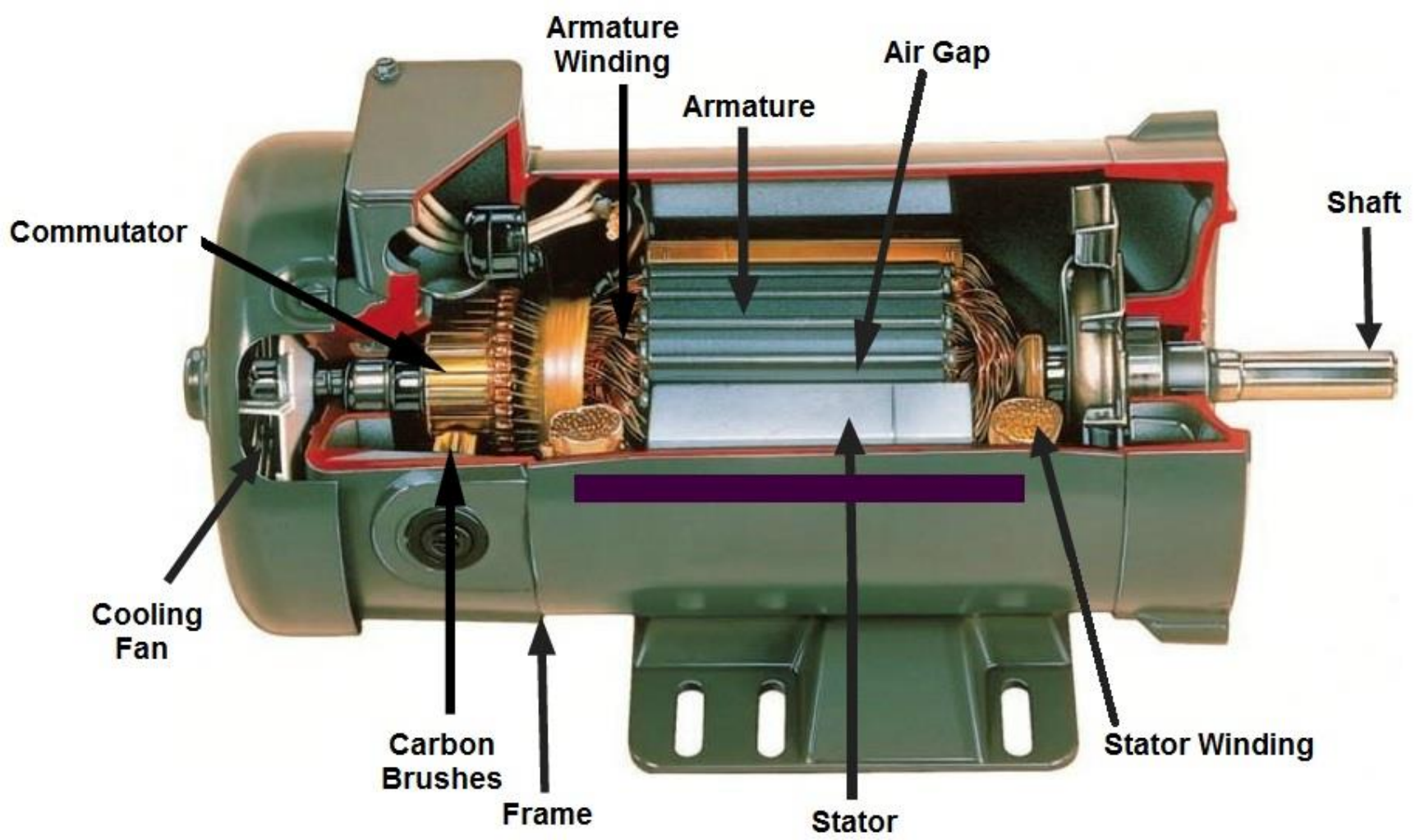


Armature winding

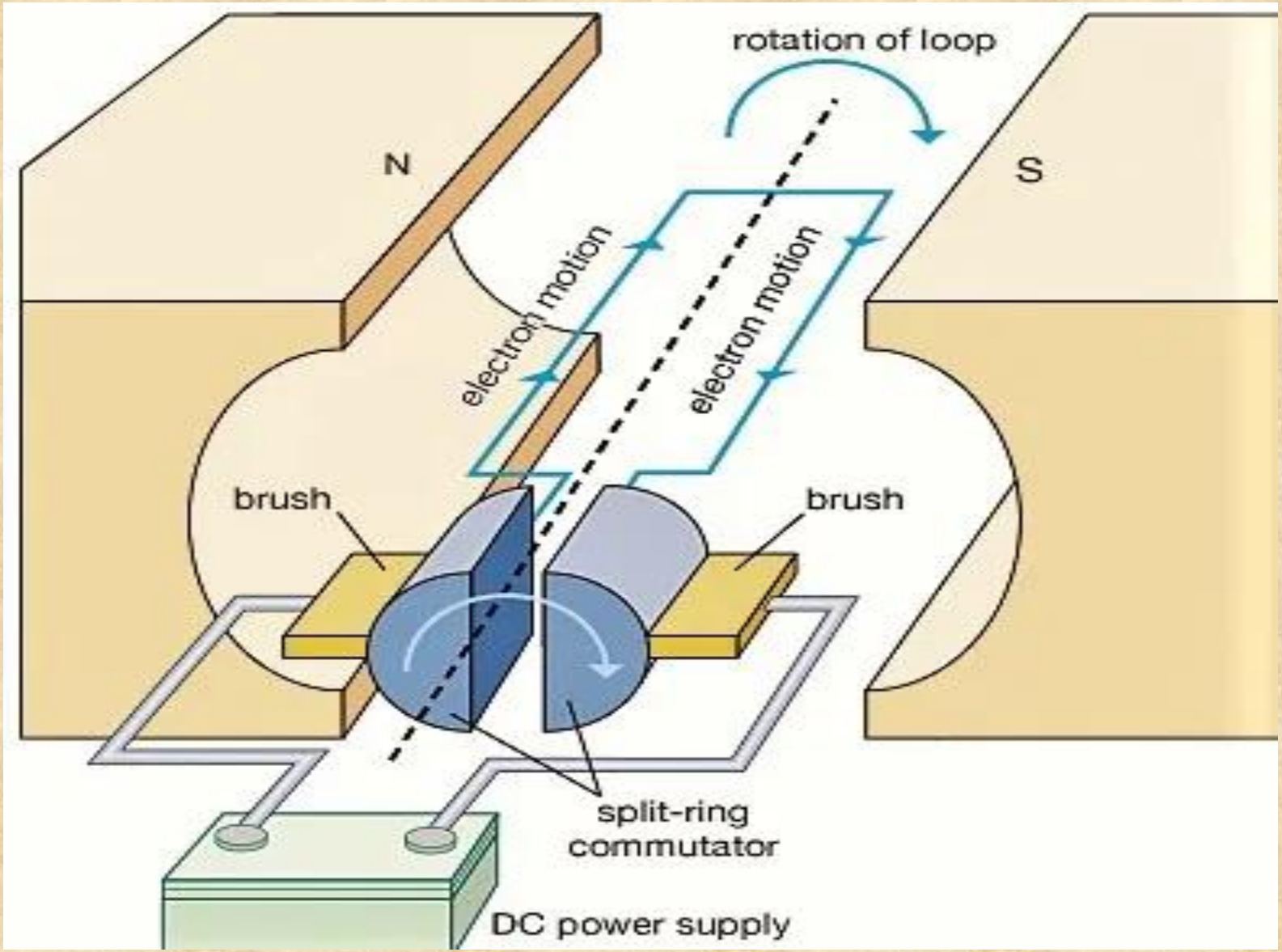


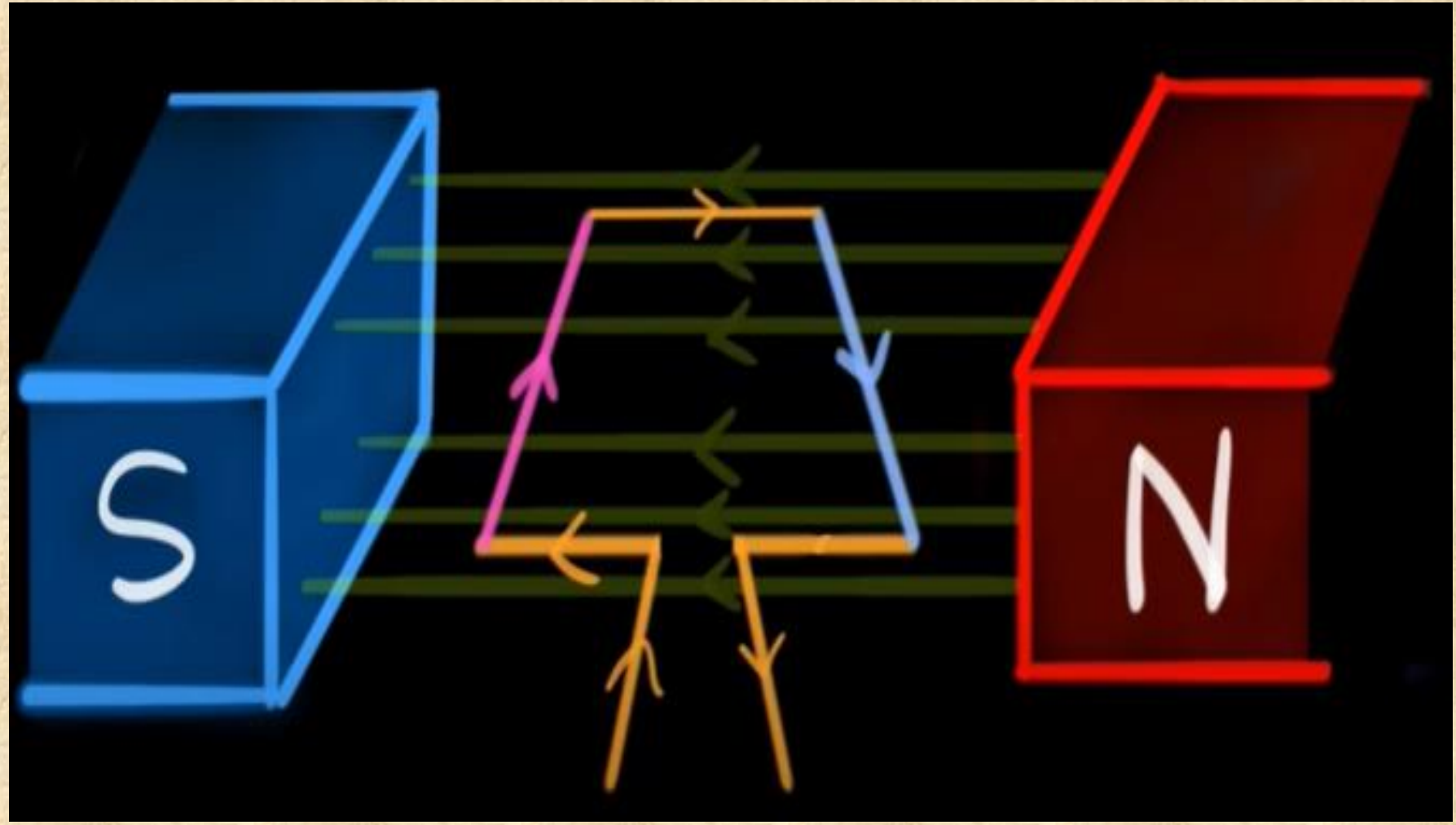
ARMATURE CORE

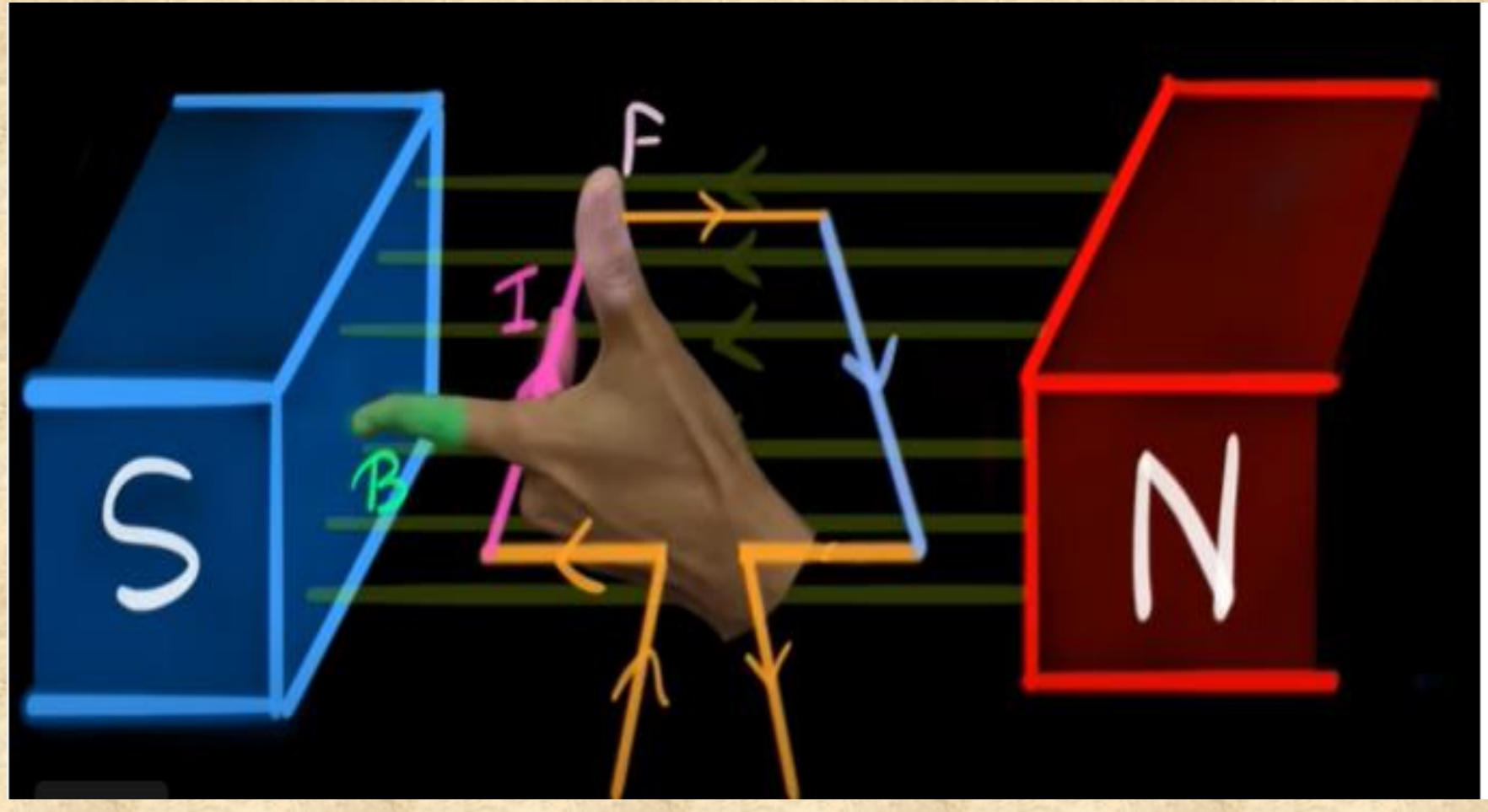
Construction of DC Machine

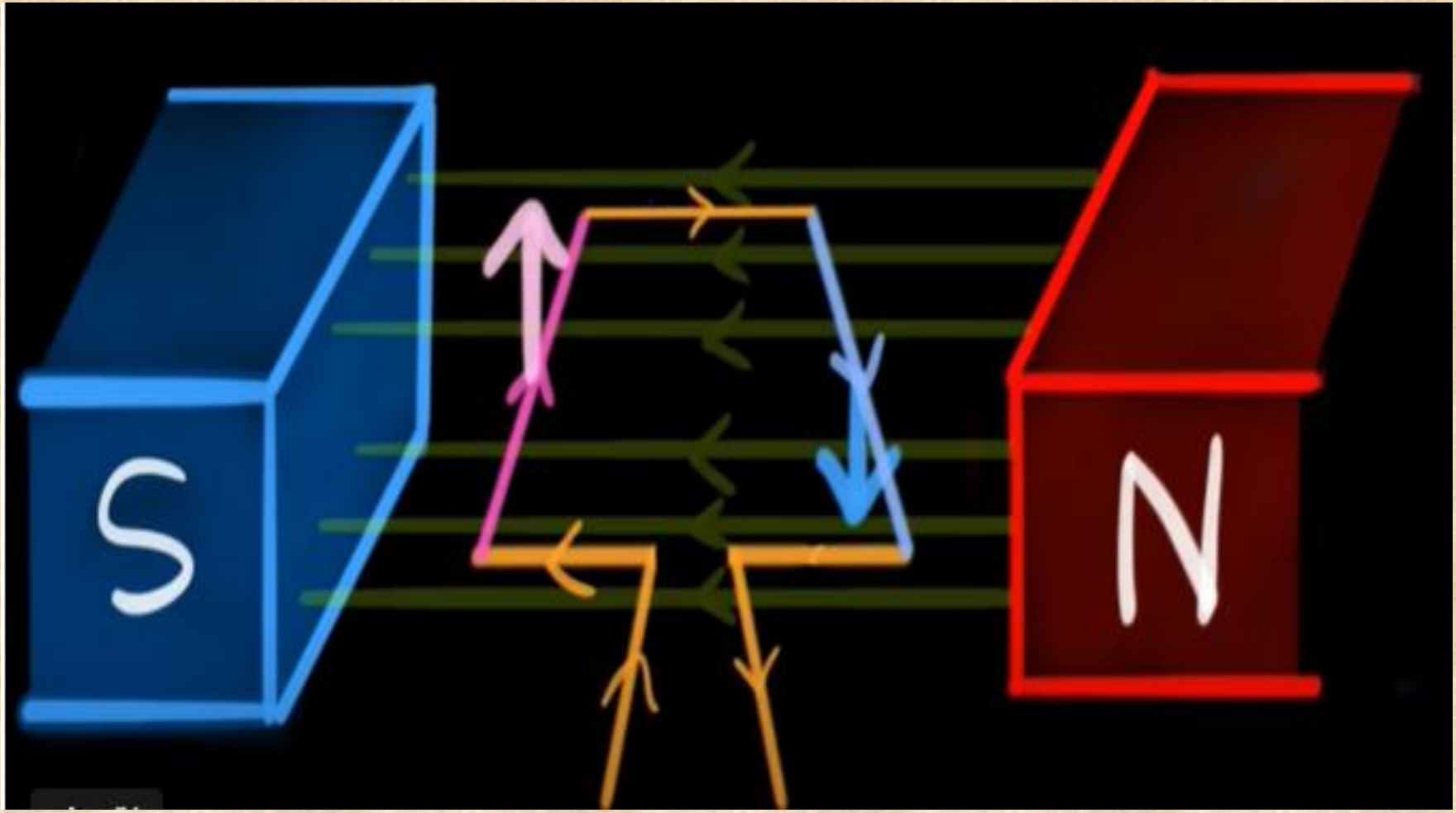


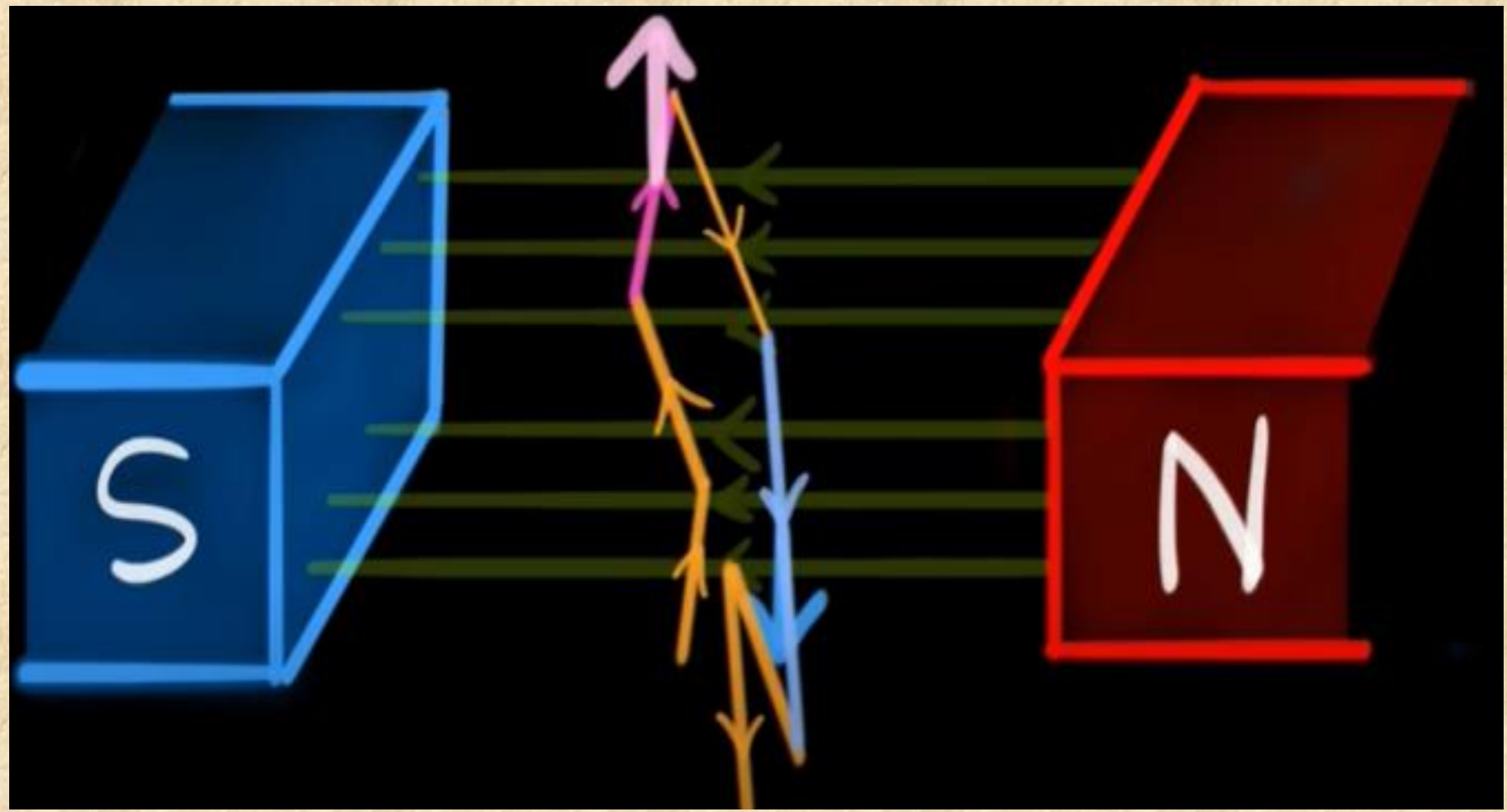
WORKING OF DC GENERATOR

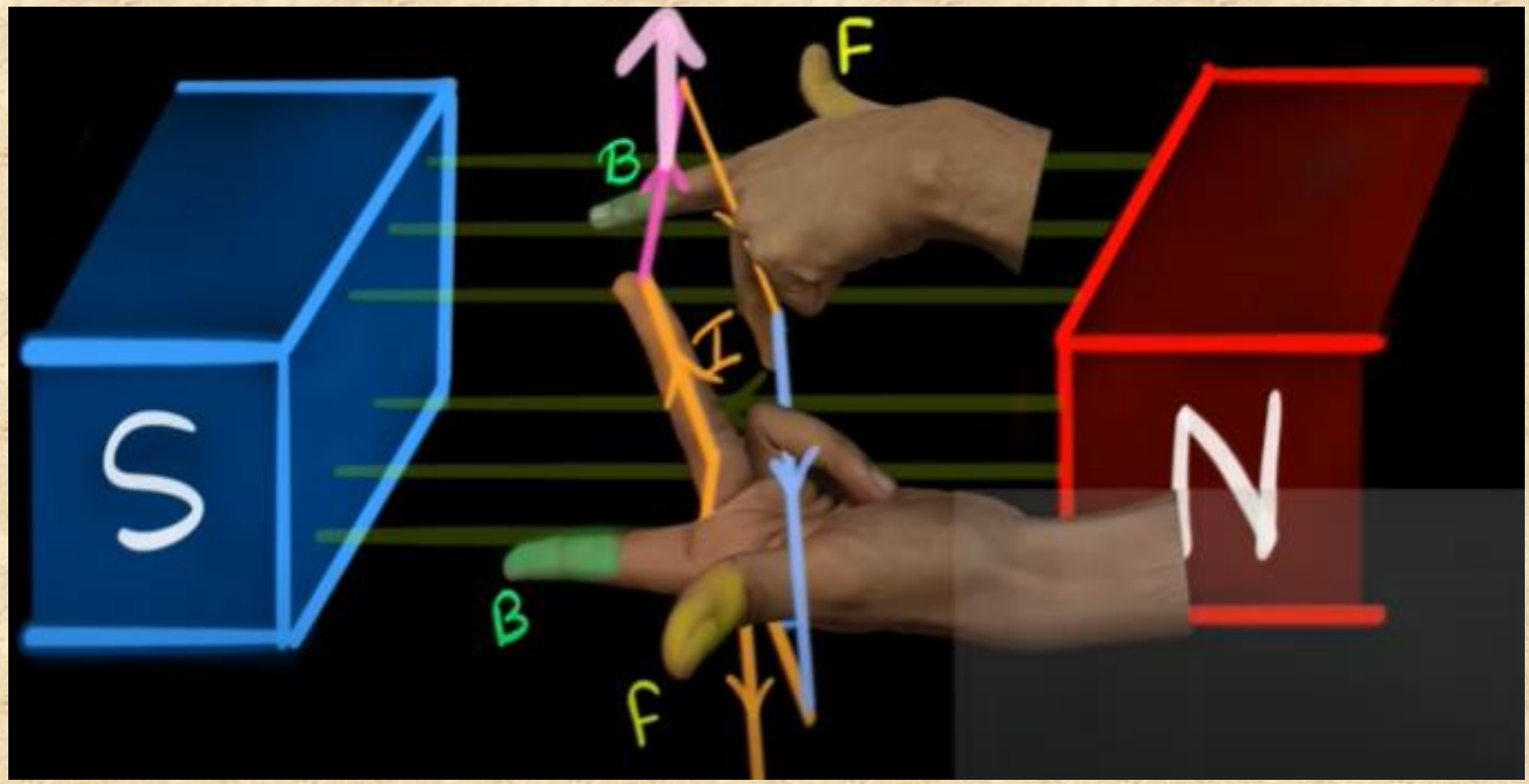


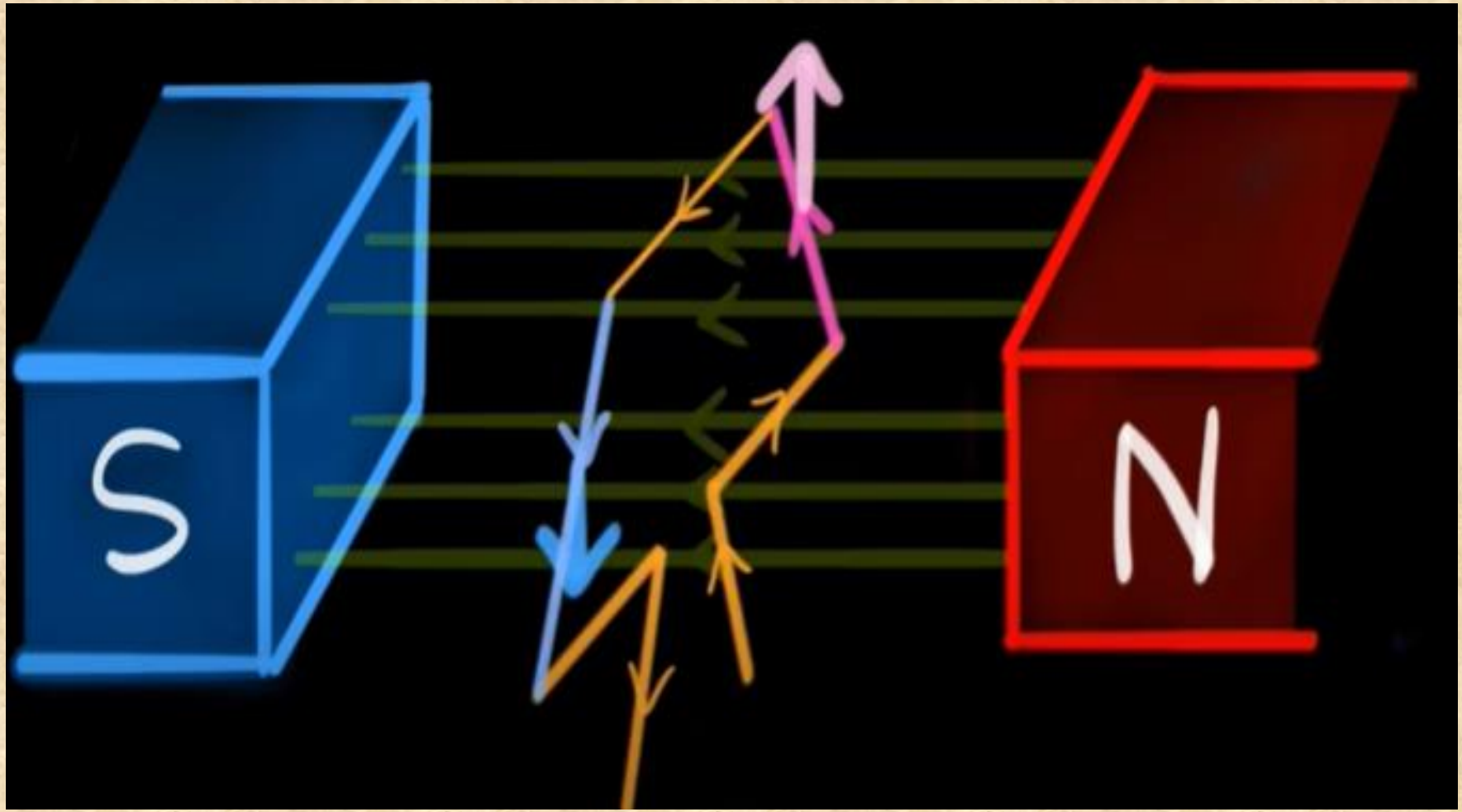

S
N

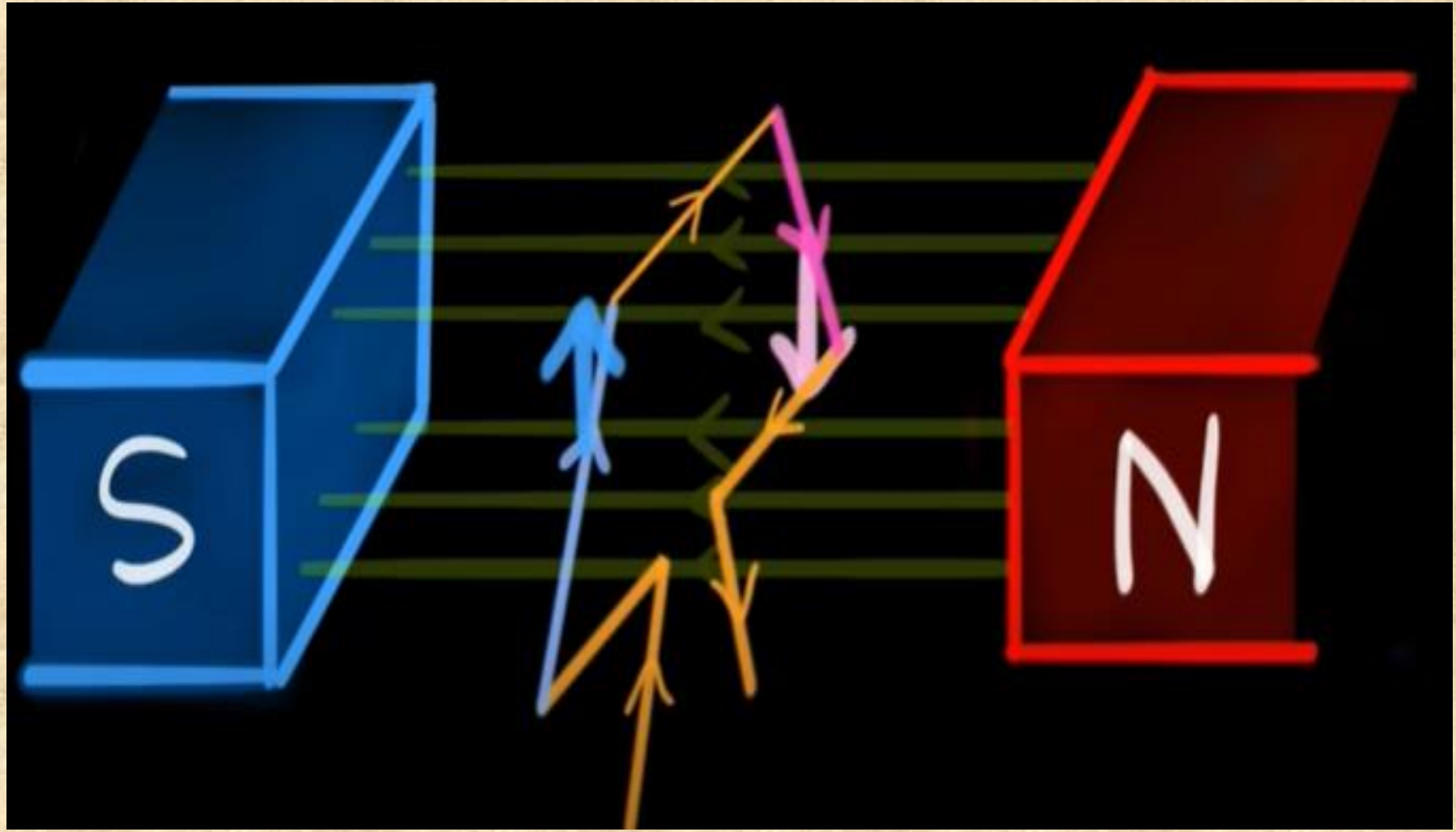

F
I
B
S
N

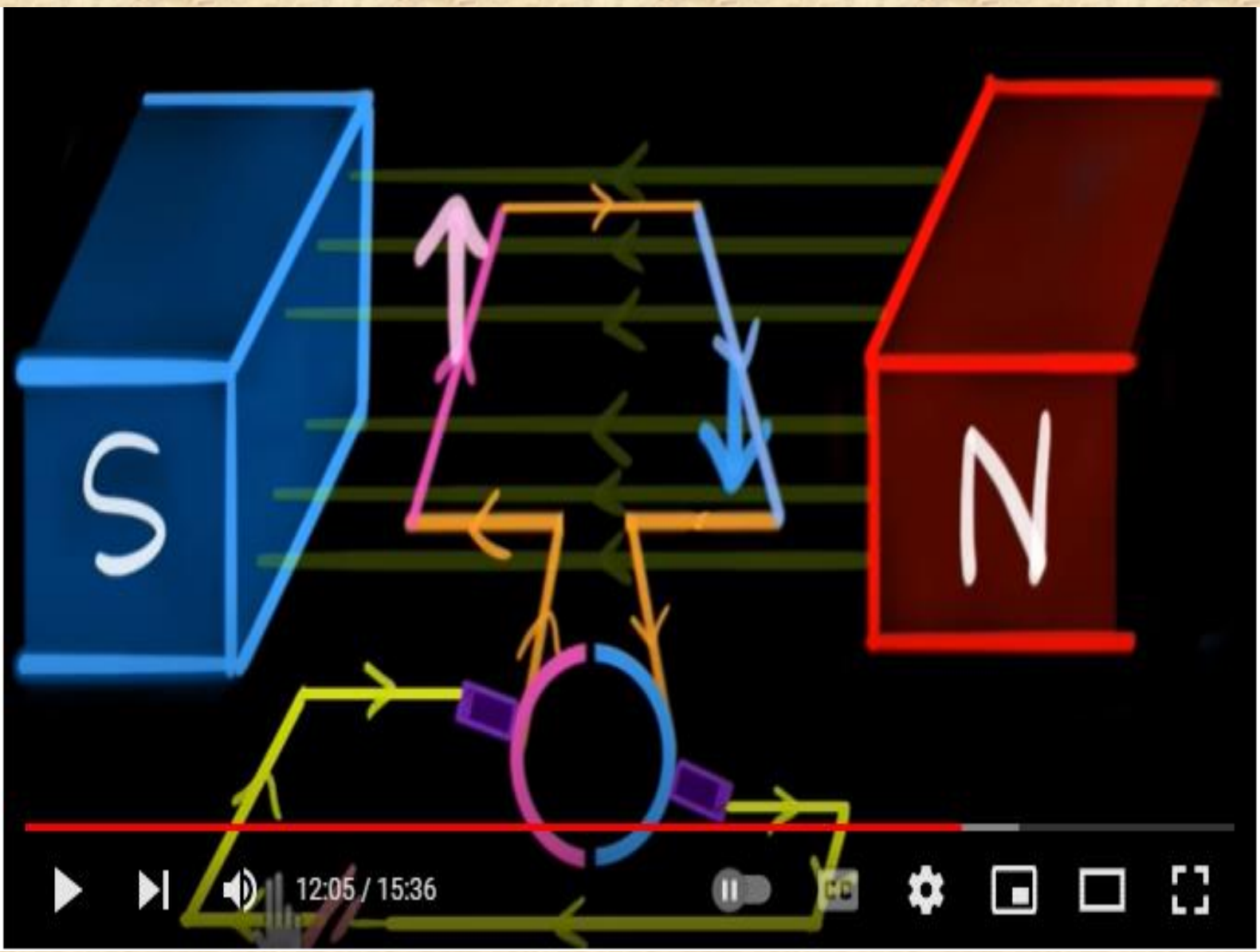

S
N


S
N


F
B
I
S
N
B
F


S
N


S
N


S
N
12:05 / 15:36


S
N
14:02 / 15:36

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).

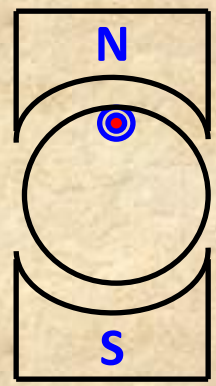
Z = Total number of Armature conductors.

A = Number of Parallel paths in the Armature winding.

According to Faradays Law,

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

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



In one Revolution of the armature,

the total flux cut by one conductor will be

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

RPM = Revolutions per Minute = N

RPS = Revolutions per Second = N / 60

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

EMF Equation of a DC Generator .....contd.

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,

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

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,

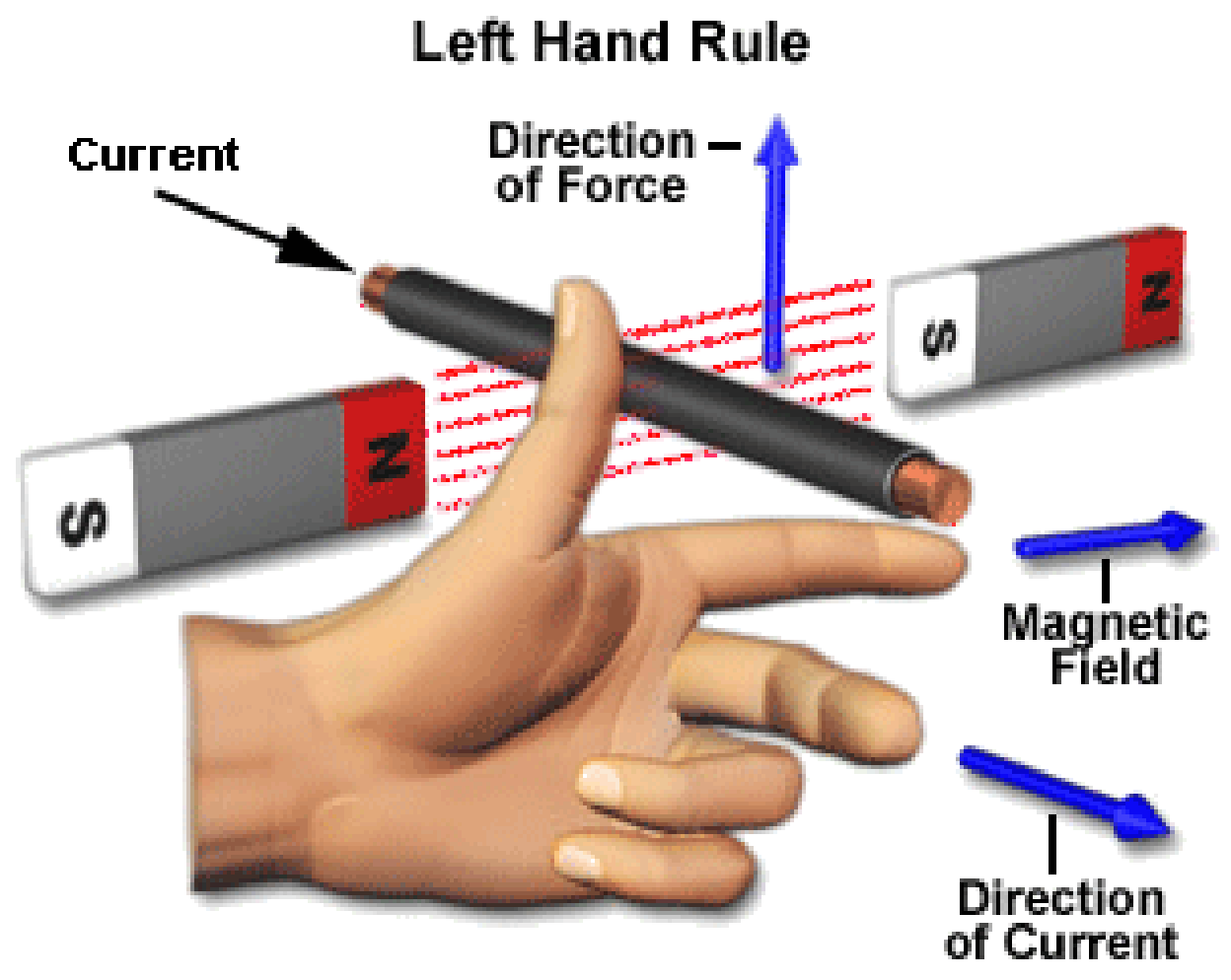
$$\text{Total } E = \frac{P\,\varphi\,N}{60} \times \frac{Z}{A} = \frac{P\,\varphi\,N\,Z}{60\,A} \quad \text{Volts}$$

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

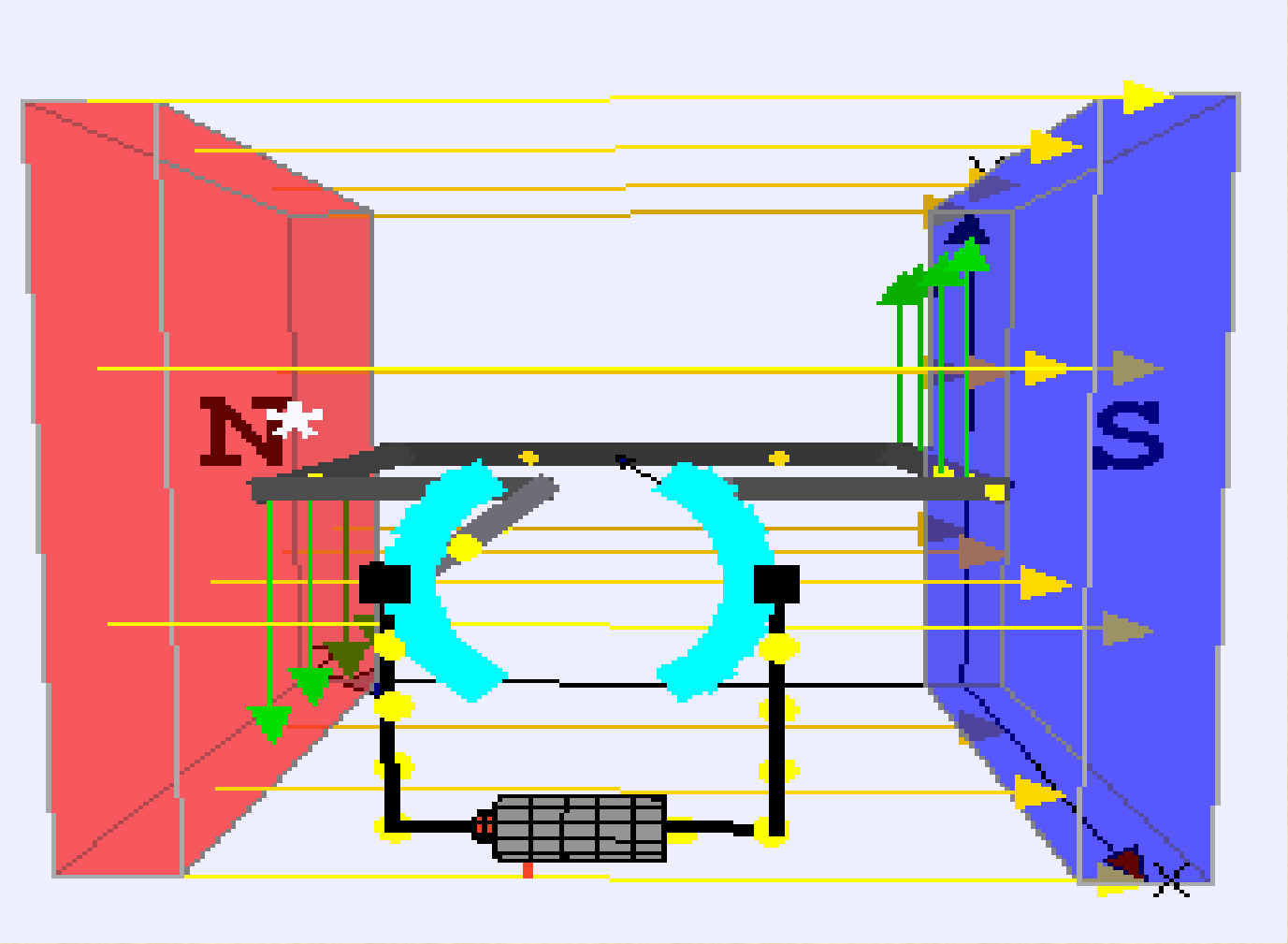
$E \propto ??$ → $E \propto \phi N$

All other parameters are constant...

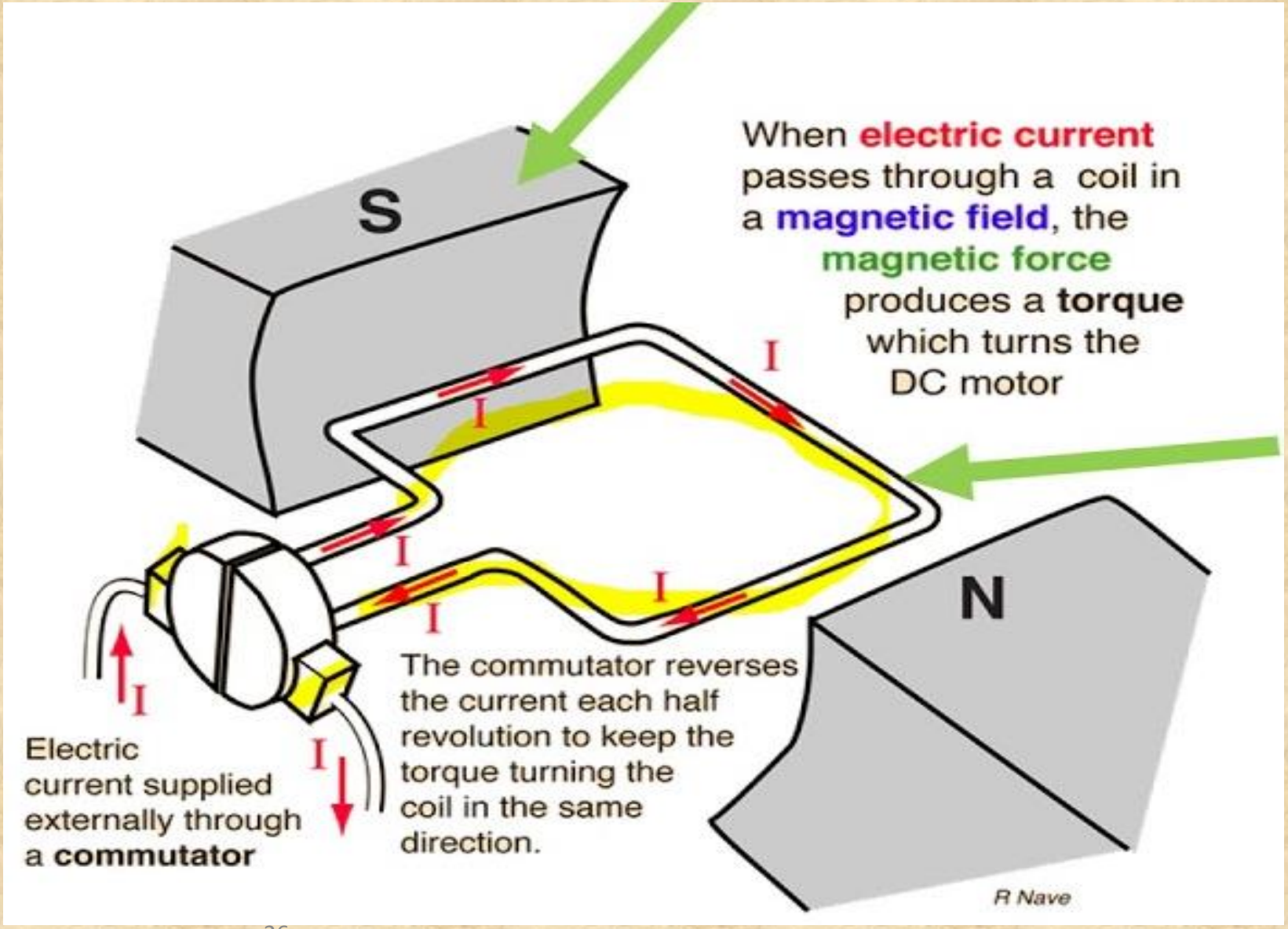
Left hand rule – Motoring action



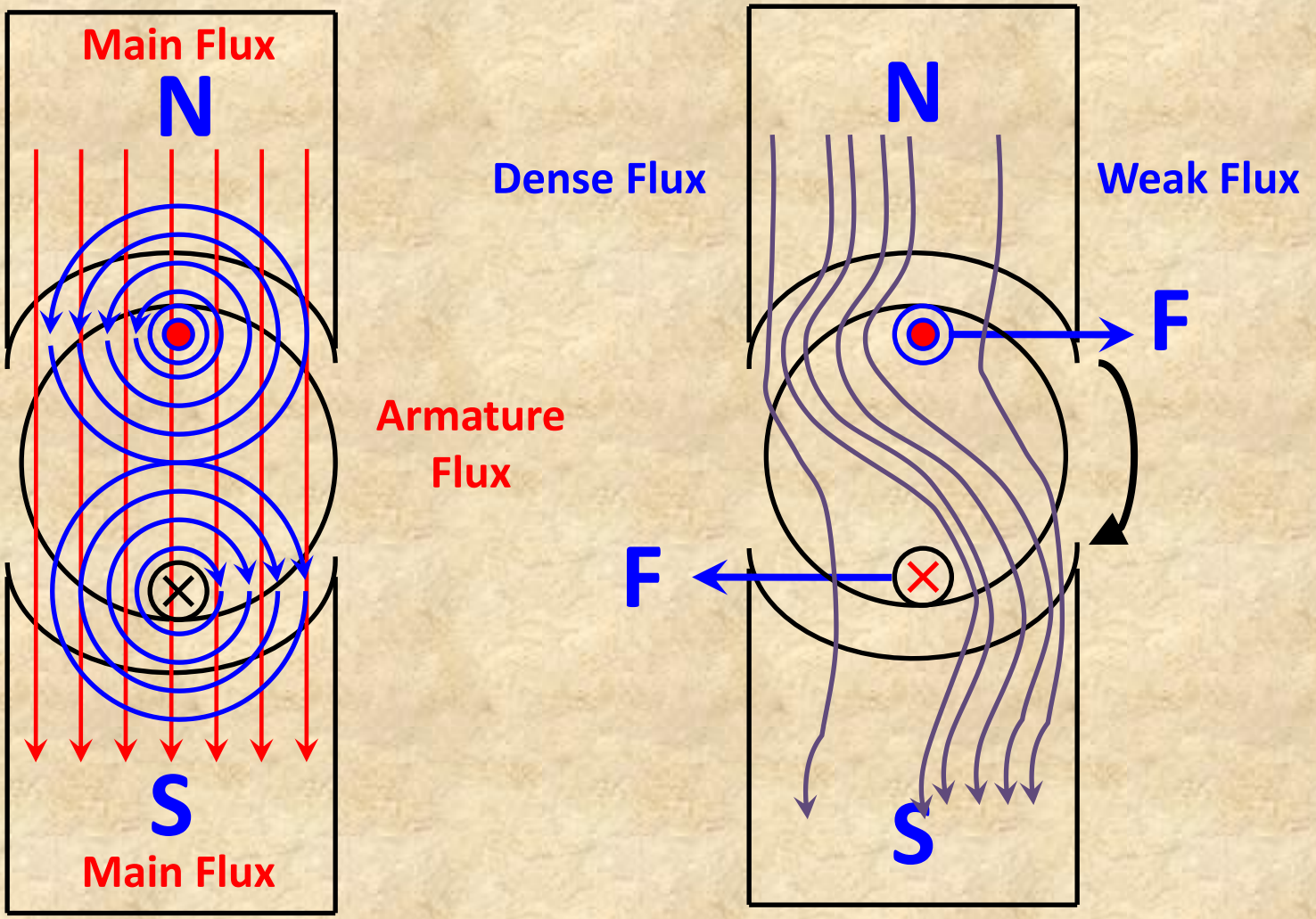
Motoring action



Motoring action

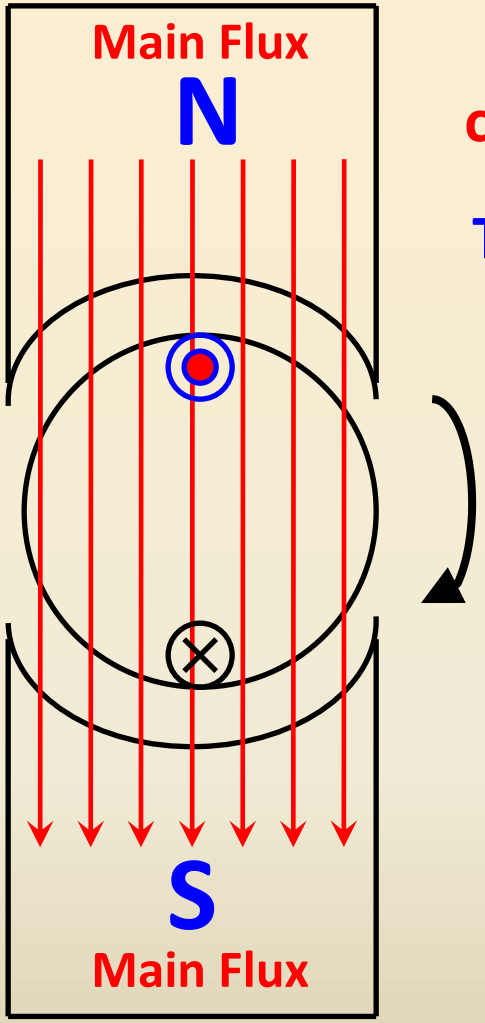


Motoring Action – How a DC motor works ?



A Couple is generated

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)

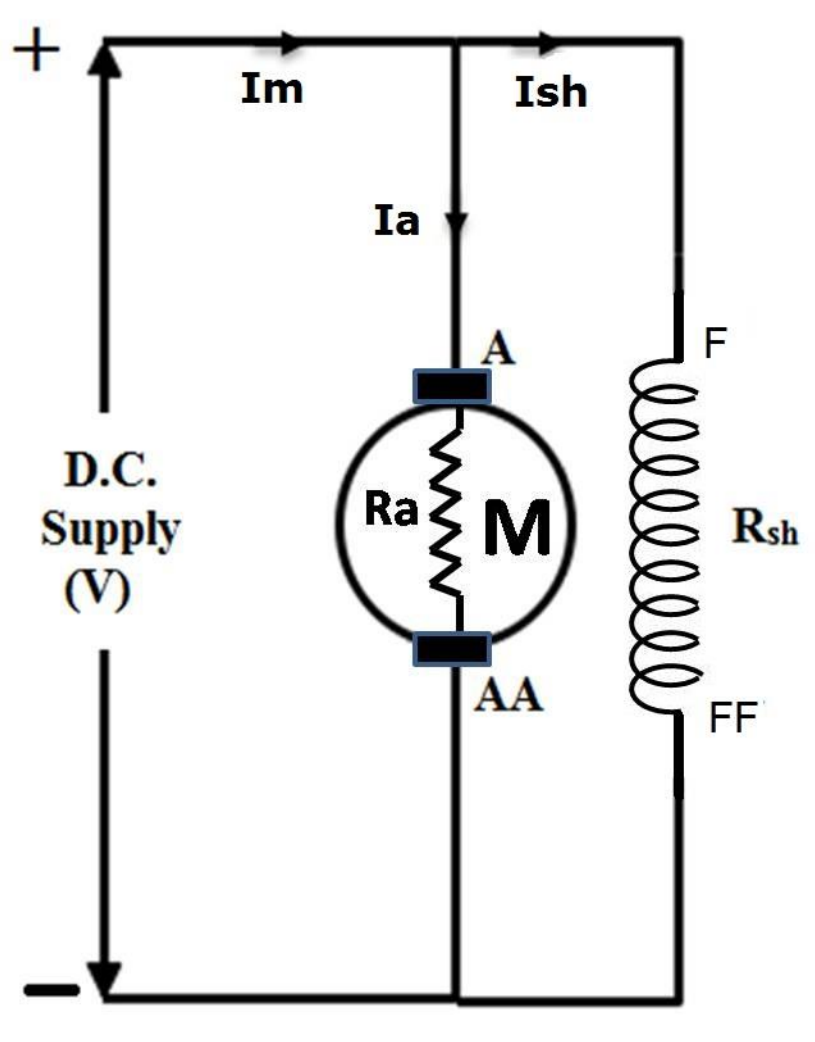
This EMF should oppose the cause producing it. (Lenz's Law)

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

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

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

DC Shunt Motor



Im – Ish = Ia

V – Ia Ra = Eb

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

V = 230 V DC

Im = 10 A (depends upon HP)

Ia = 9 Amp

Ish = 1 Amp

Ra < 1.0 ohm

Rsh = 200+ ohm

V drops at brushes also.

Eb = 227 ~ 228 V

$Eb = V - Ia\,Ra$ ..... Multiply both sides by Ia

$Eb\,Ia = V\,Ia - Ia^2\,Ra$ .....(1)

This is a power equation now...

Eb Ia = Input – Loss (Heat generated)

Thus..... Eb Ia = Output (IMP parameter)

But $Eb = P \phi N Z / 60 A$ ..... Substitute in (1)

$$Eb = \frac{P \phi N Z}{60 A} \times Ia = T \times \omega$$ ...(Elect to Mech)

But $\omega = 2\pi N / 60$

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

This is called as the Torque equation of DC Motor

$T \alpha \phi Ia$ ...(Other parameters are constant)

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

$$Eb \propto \phi N$$

$$N \propto Eb / \phi$$

$$N \propto \frac{Eb}{\varphi} = \frac{V - Ia\,Ra}{\varphi}$$

Effect of loading on the motor speed

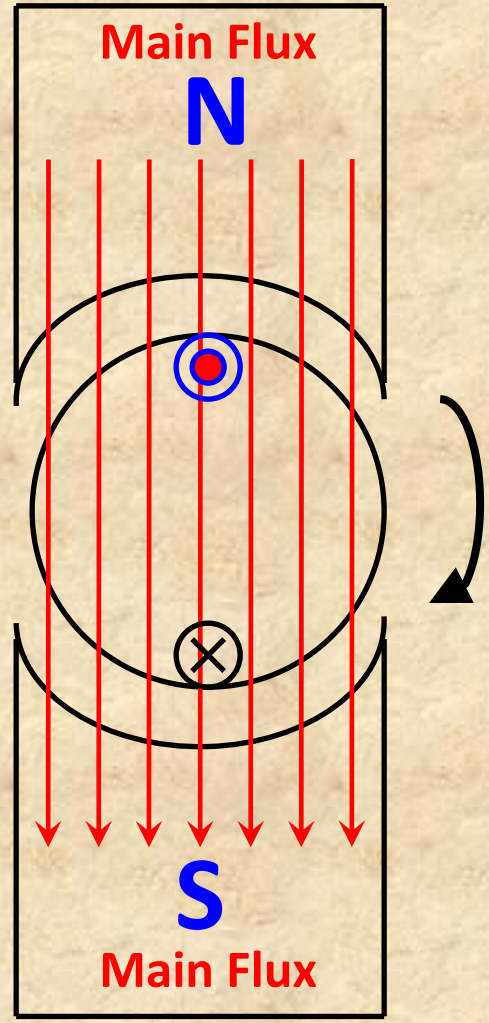
$$N \downarrow \alpha \frac{V - Ia \uparrow Ra}{\varphi}$$

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

$$N \uparrow \alpha \frac{V - Ia \downarrow Ra}{\varphi}$$

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

Direction of rotation of DC motor

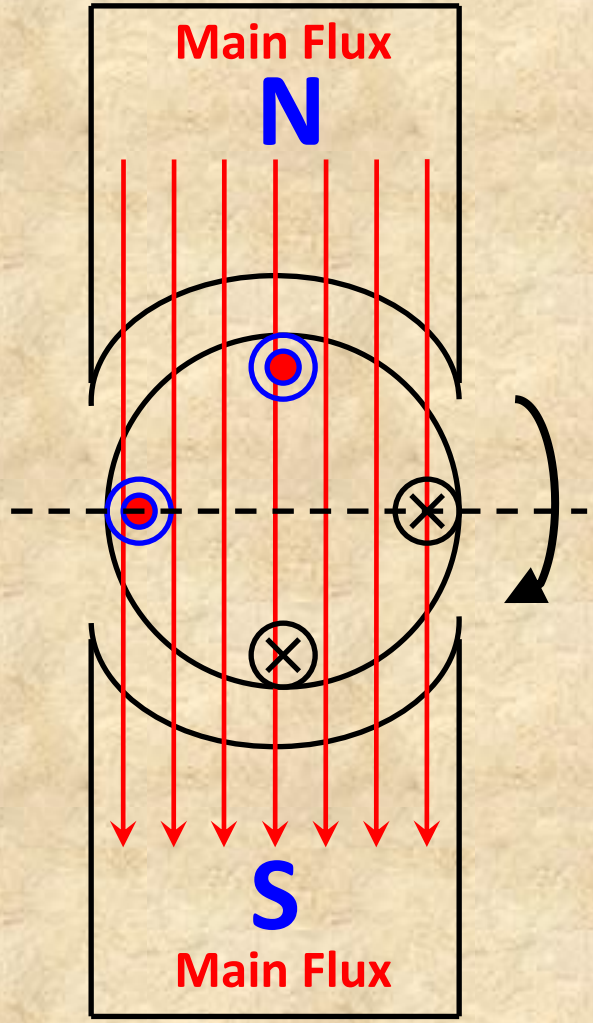


Assume that the motor starts and goes through 180^0 of rotation.

So, what is the new direction ????

Same or Reversed ????

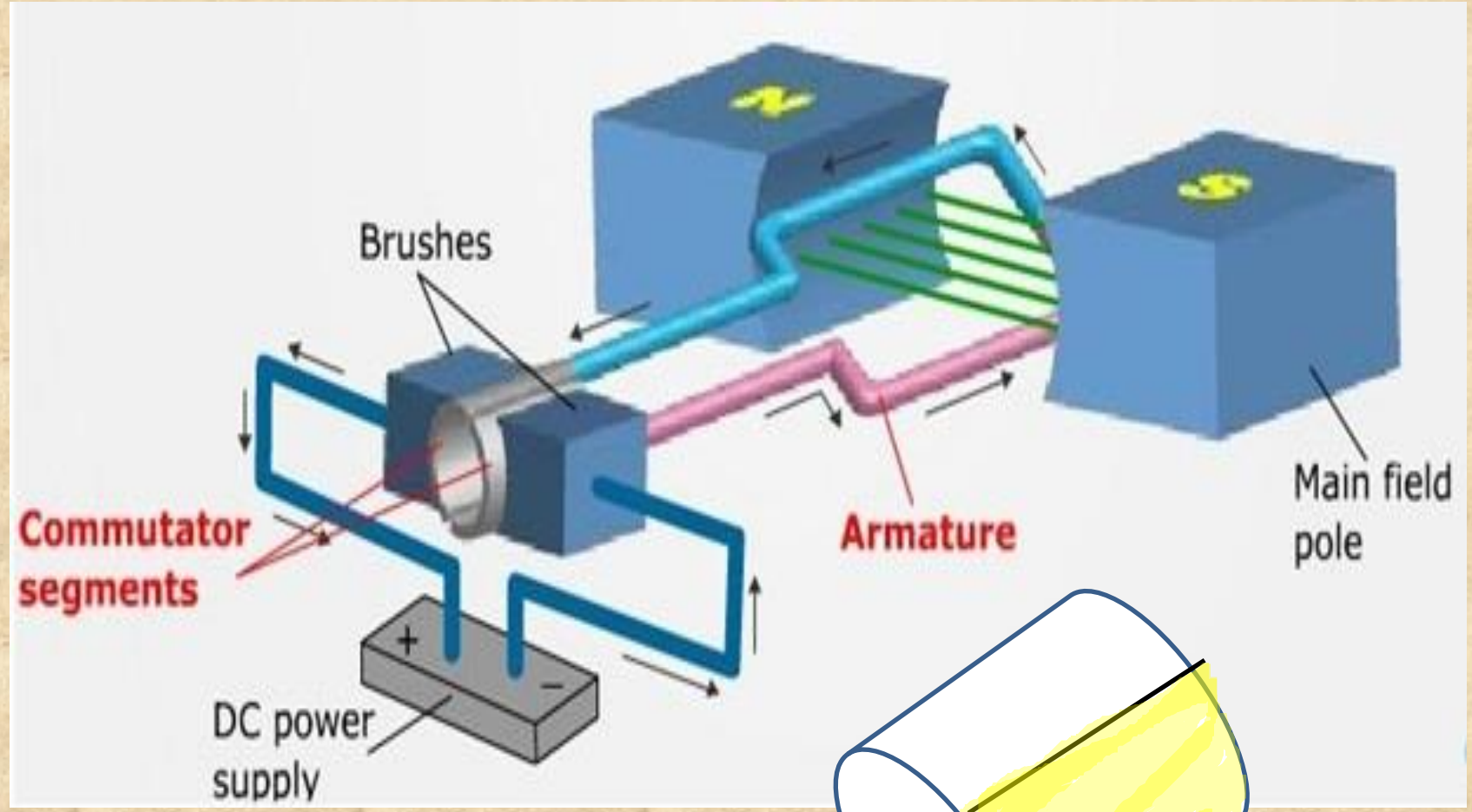
How do we get a unidirectional rotation ?



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.

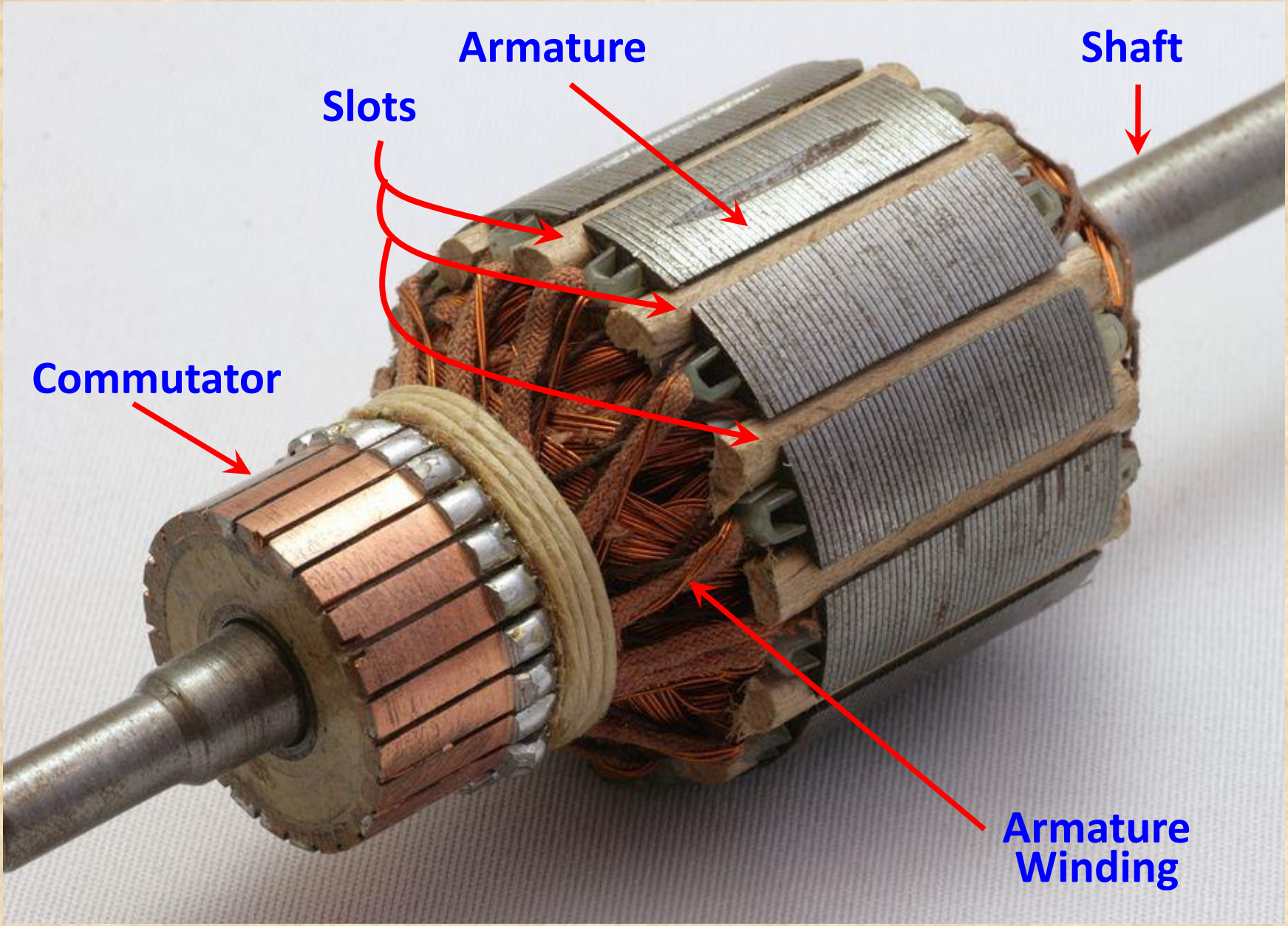
This amazing change takes place because the **COMMUTATOR !**

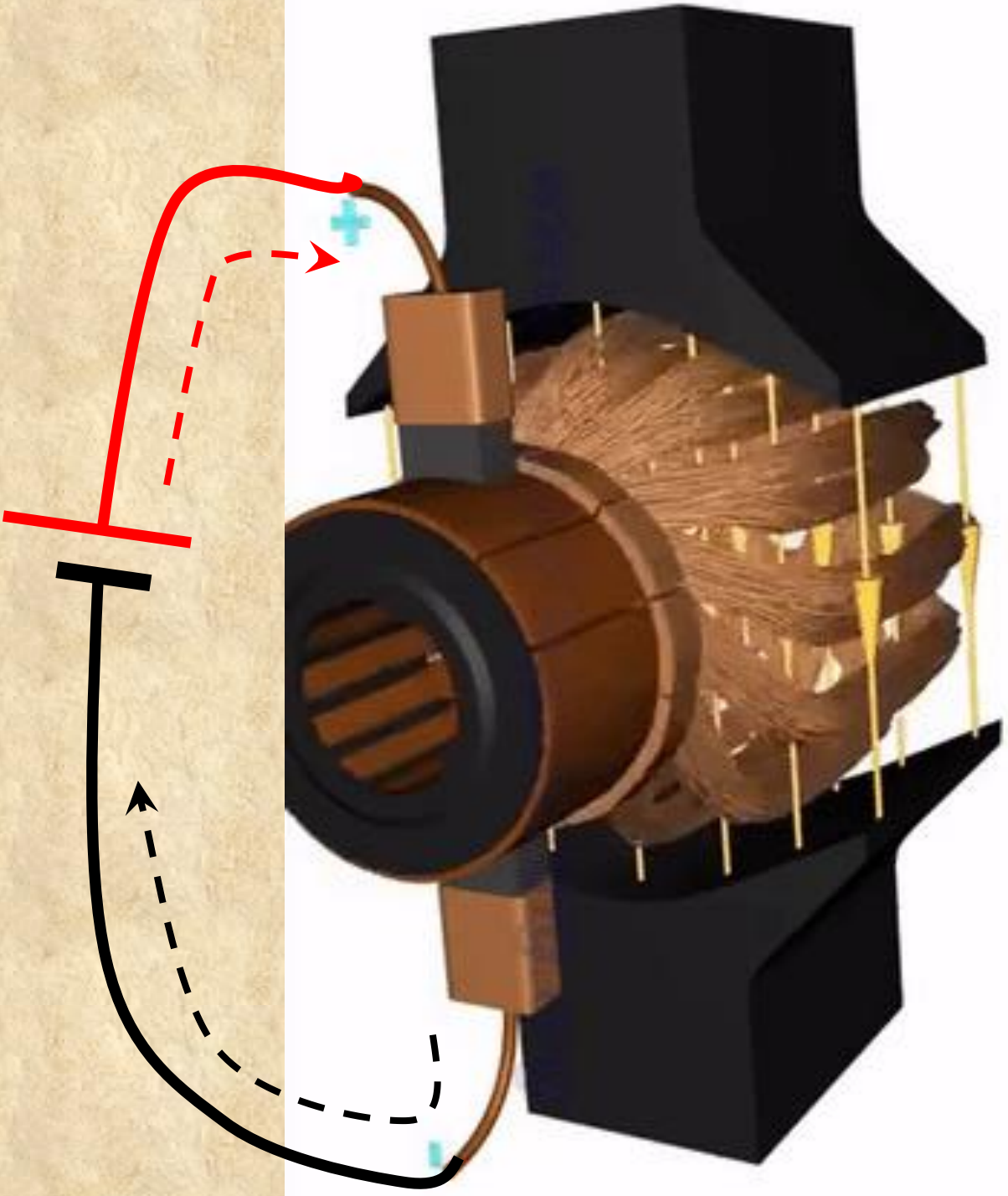


Commutator is divided into 2 halves called as segments.

Practically,

no. of segments = no. of slots in the armature


Armature
Shaft
Slots
Commutator
Armature
Winding



DC Motor characteristics –

$$N \alpha \frac{Eb}{\varphi} = \frac{V - Ia\,Ra}{\varphi}$$

$$N \alpha \frac{1}{Ia}$$

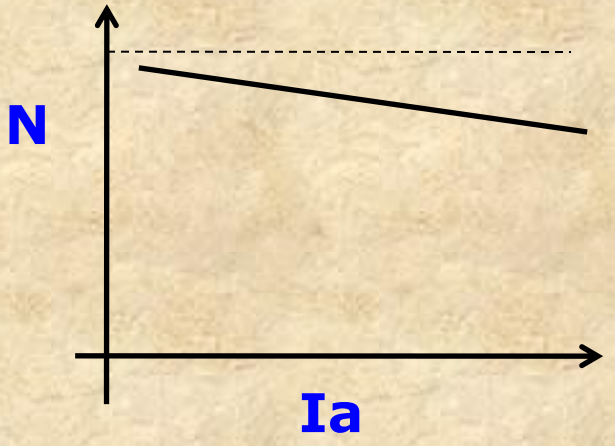
$$\text{Thus..... } T = \frac{1}{2\pi} \times \frac{P \phi Z\ Ia}{A}$$

$$T \alpha Ia$$

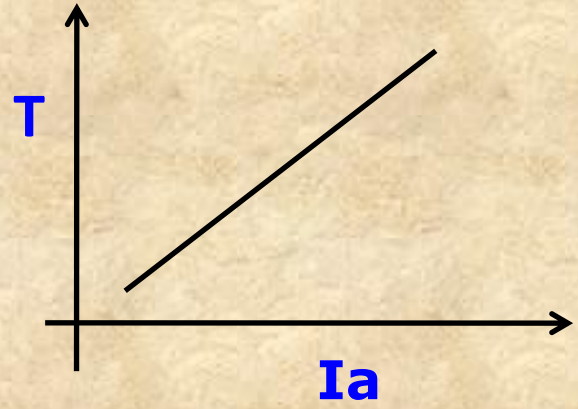
Characteristics are graphical relations between Ia, T and N

DC Motor characteristics –

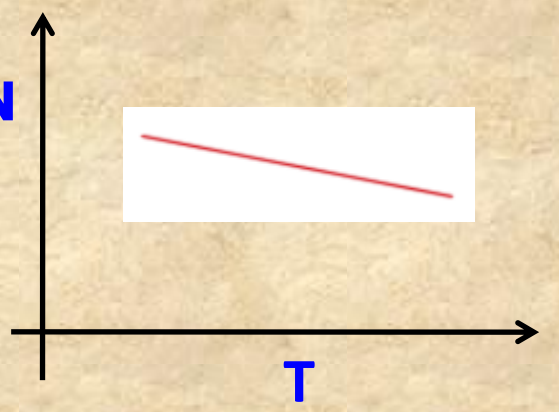
$$N \propto \frac{1}{Ia}$$



$$T \propto Ia$$

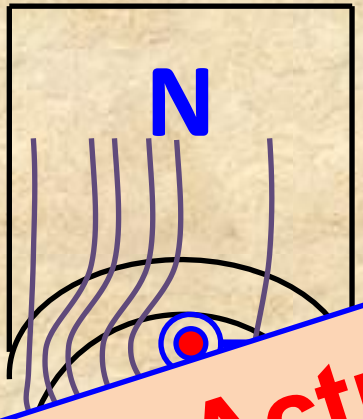


Draw a graph for the relation between T and N.



Vishwakarma Institute of Technology

FY - Department of Engineering, Sciences and Humanities



Actuators – 3.3
DC Brush Motors
Thanks !

FY – DESH – VIT