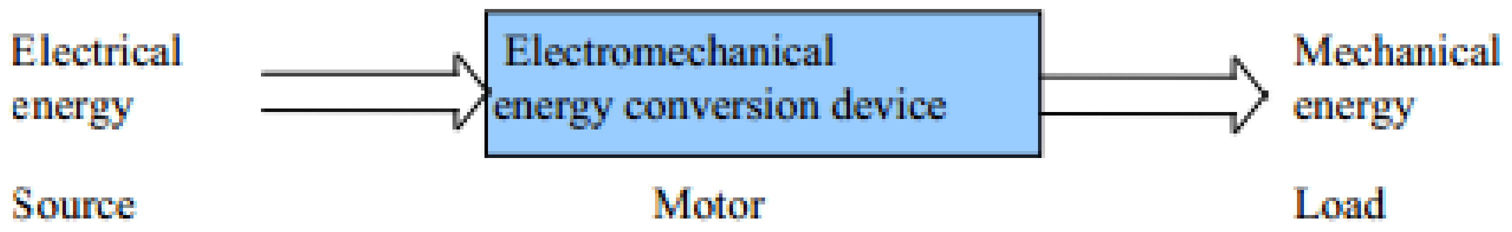
DC MOTOR

Prashant Ambadekar

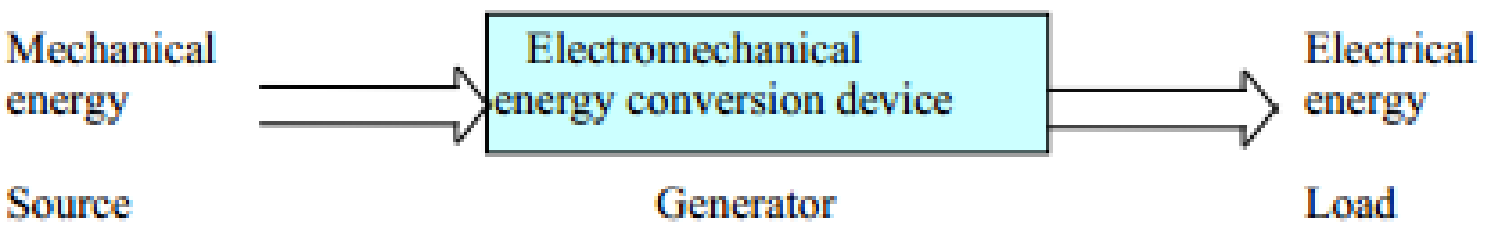
Electric Motor:

The input is electrical energy (from the supply source), and the output is mechanical energy (to the load).



Electric Generator:

The Input is mechanical energy (from the prime mover), and the output is electrical energy.



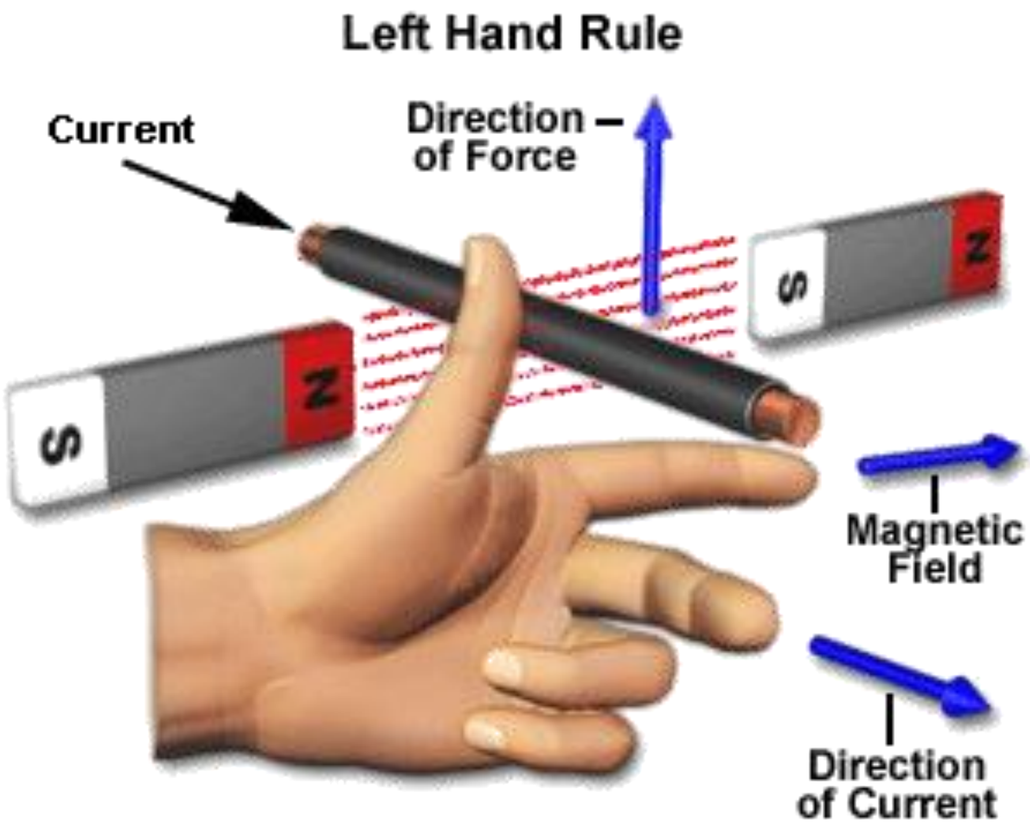
- A DC motor in simple words is a device that converts direct current (electrical energy) into mechanical energy.
- It is a electromechanical device.

Applications:

- Toys, Robots
- Lathes, Drills, Boring mills, Shapers
- Spinning and Weaving machines
- Electric traction
- Cranes, Elevators
- Air compressor
- Vacuum cleaner, Hair drier
- Sewing machine
- Automotive windscreen wipers and fans.
- Train and automotive traction applications

FLEMING'S LEFT HAND RULE

If we extend the index finger, middle finger and thumb of our left hand in such a way that the current carrying conductor is placed in a magnetic field (represented by the index finger) is perpendicular to the direction of current (represented by the middle finger), then the conductor experiences a force in the direction (represented by the thumb) mutually perpendicular to both the direction of field and the current in the conductor.

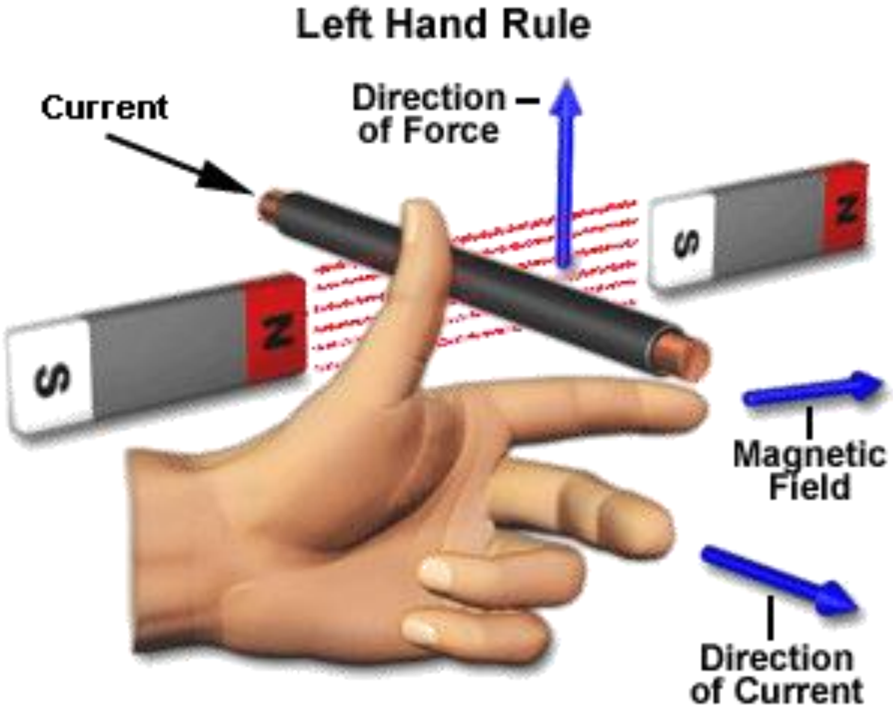


FLEMING'S LEFT HAND RULE

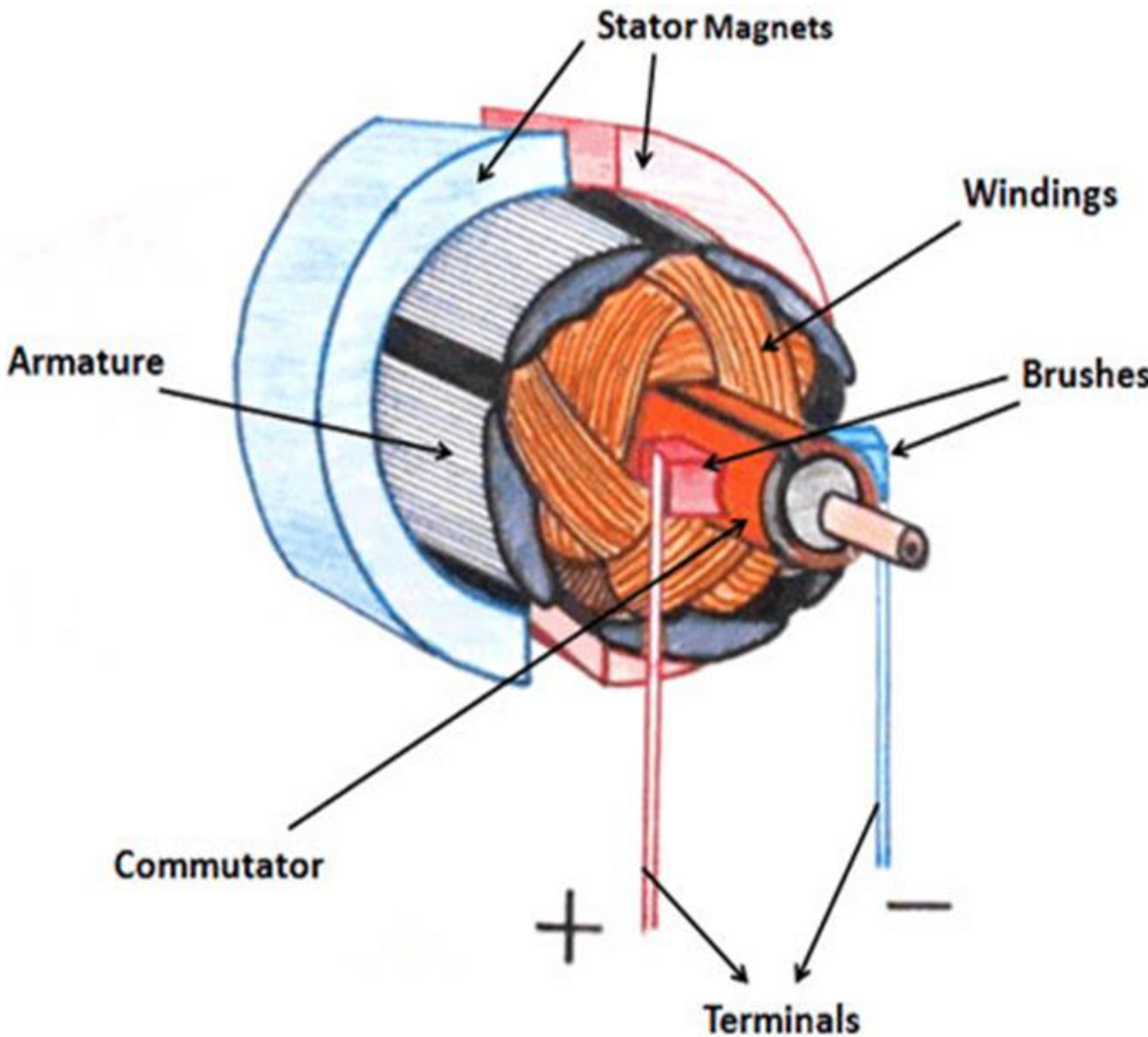
- A portion of a conductor of length L placed in a uniform horizontal magnetic field strength B, produced by two magnetic poles N and S.

- If I is the current flowing through this conductor, the magnitude of the force acts on the conductor is,

$$F = BIL$$



CONSTRUCTION OF DC MOTOR



Two Basic parts:

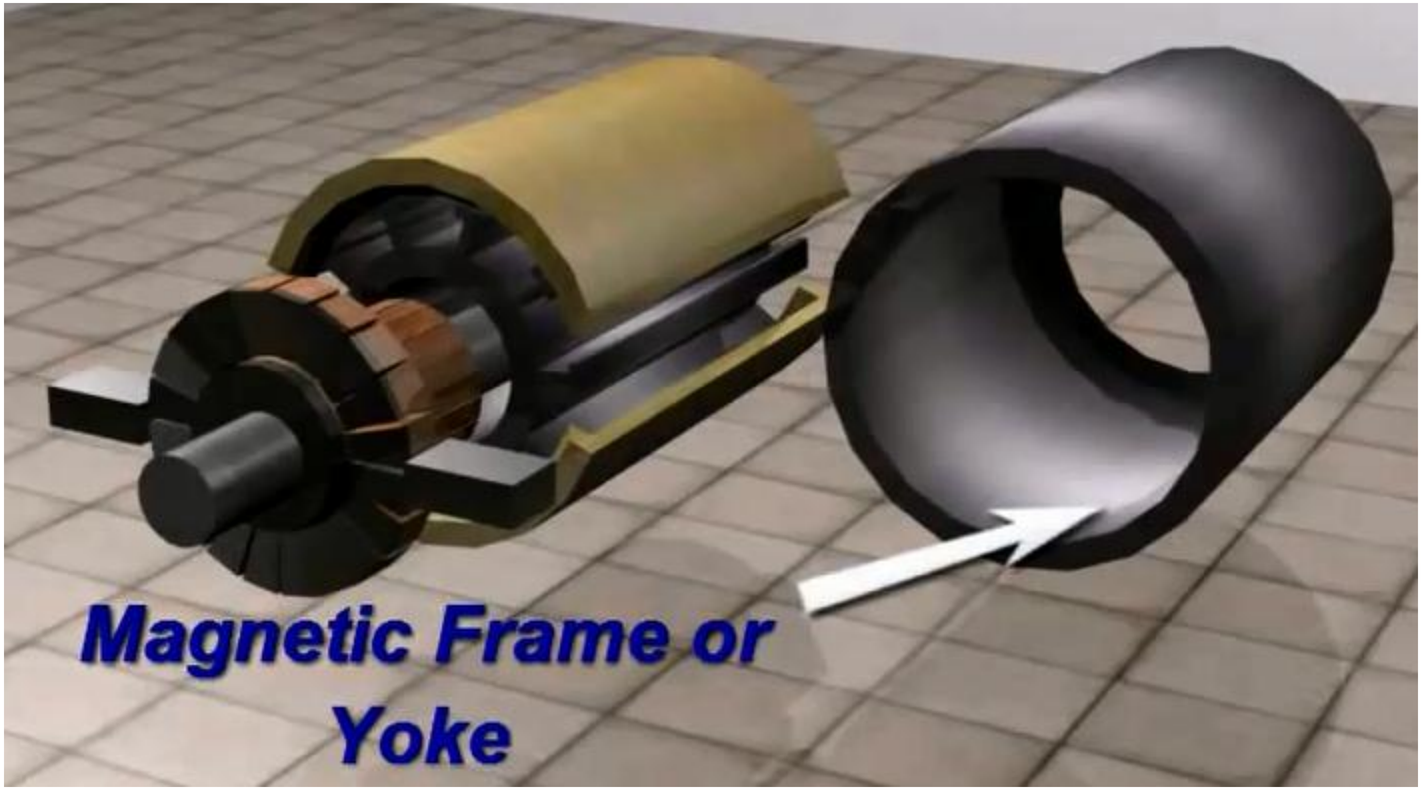
Stator:

- To produce the magnetic field.
- Two magnets

Rotor / Armature:

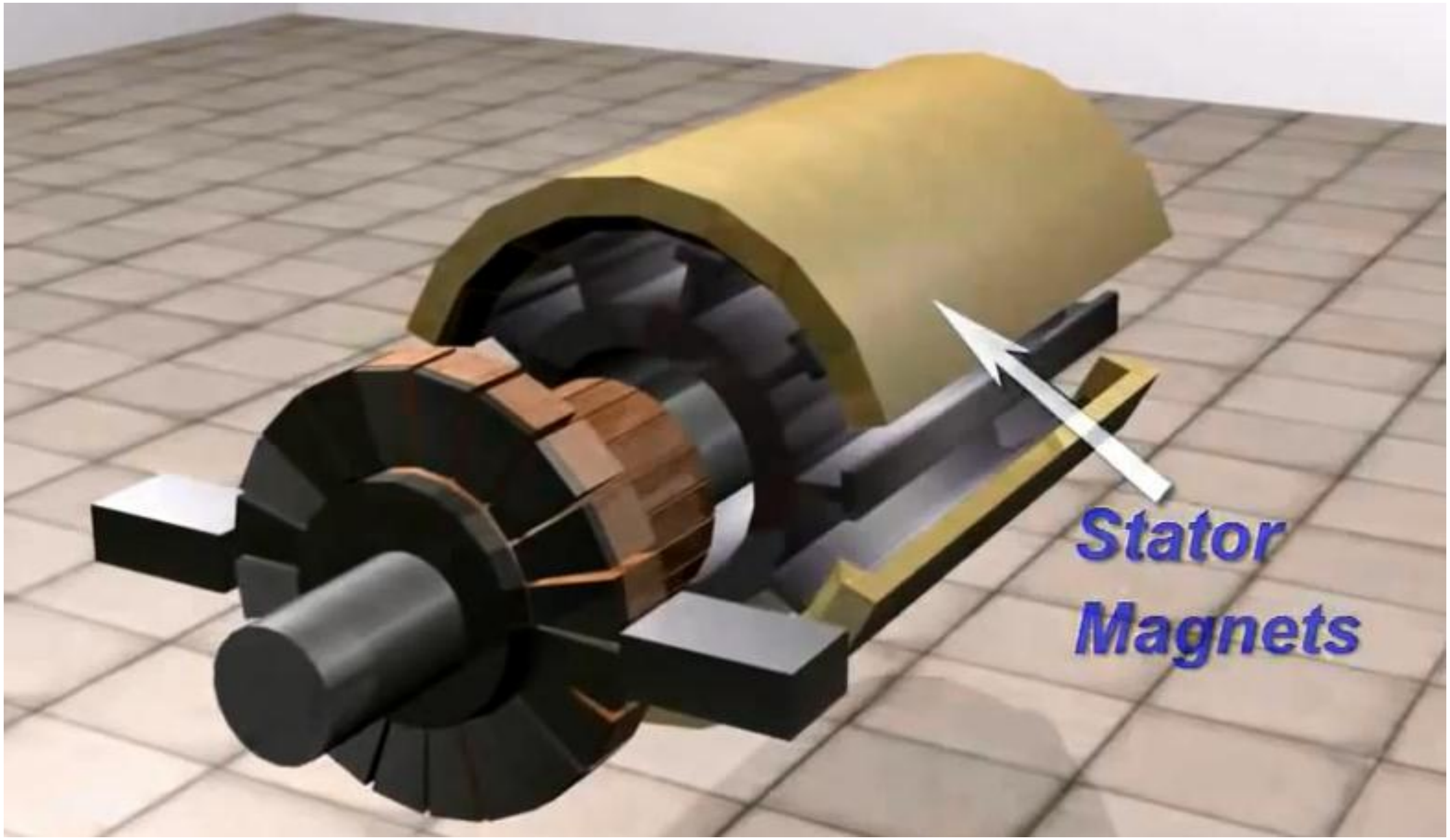
- To act as conductor

CONSTRUCTION OF DC MOTOR

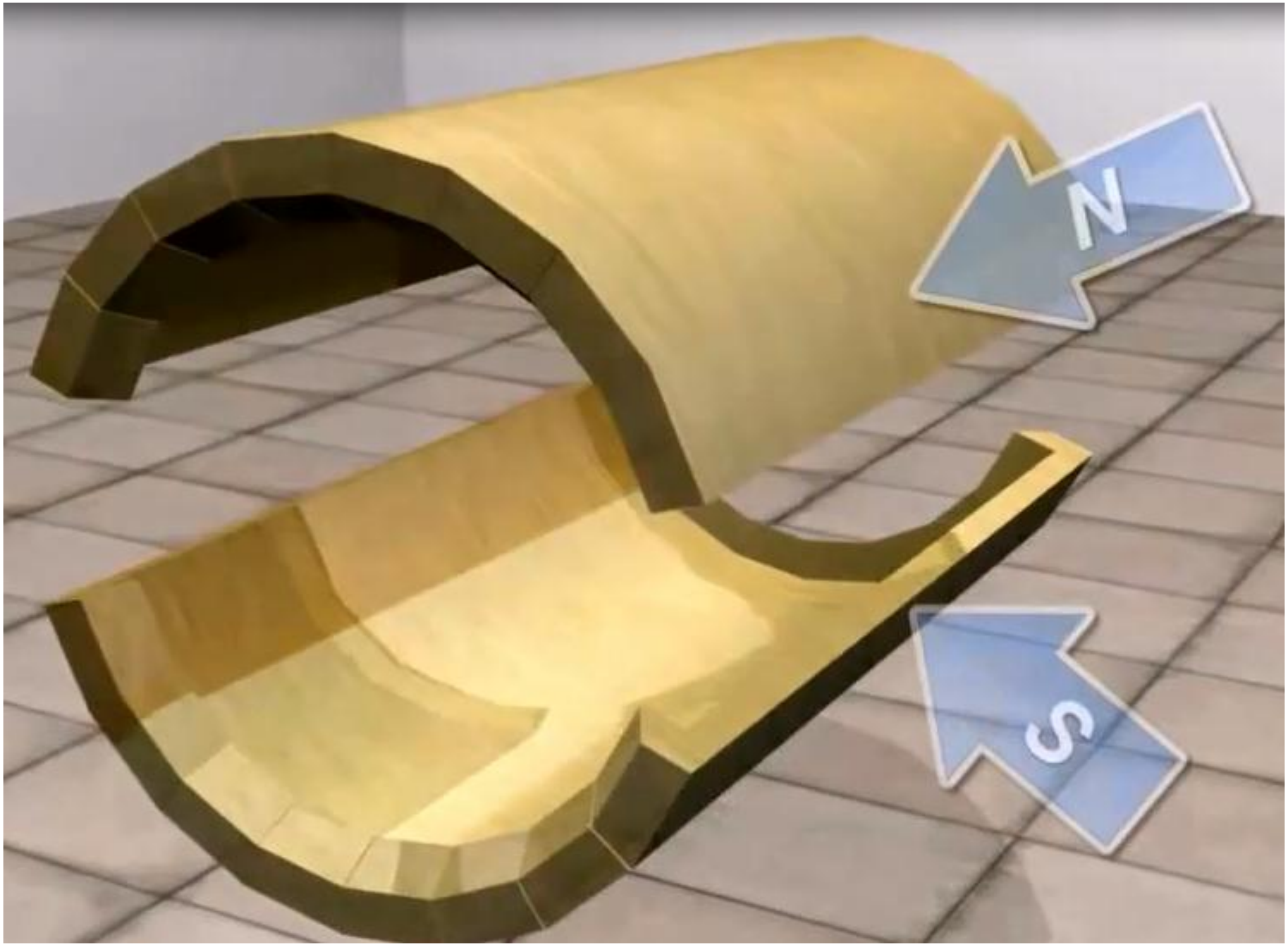


- It houses the field system and supports the armature through bearings.
- It also acts as a protective cover for the machine and protect it from any outside disturbances.

CONSTRUCTION OF DC MOTOR



CONSTRUCTION OF DC MOTOR



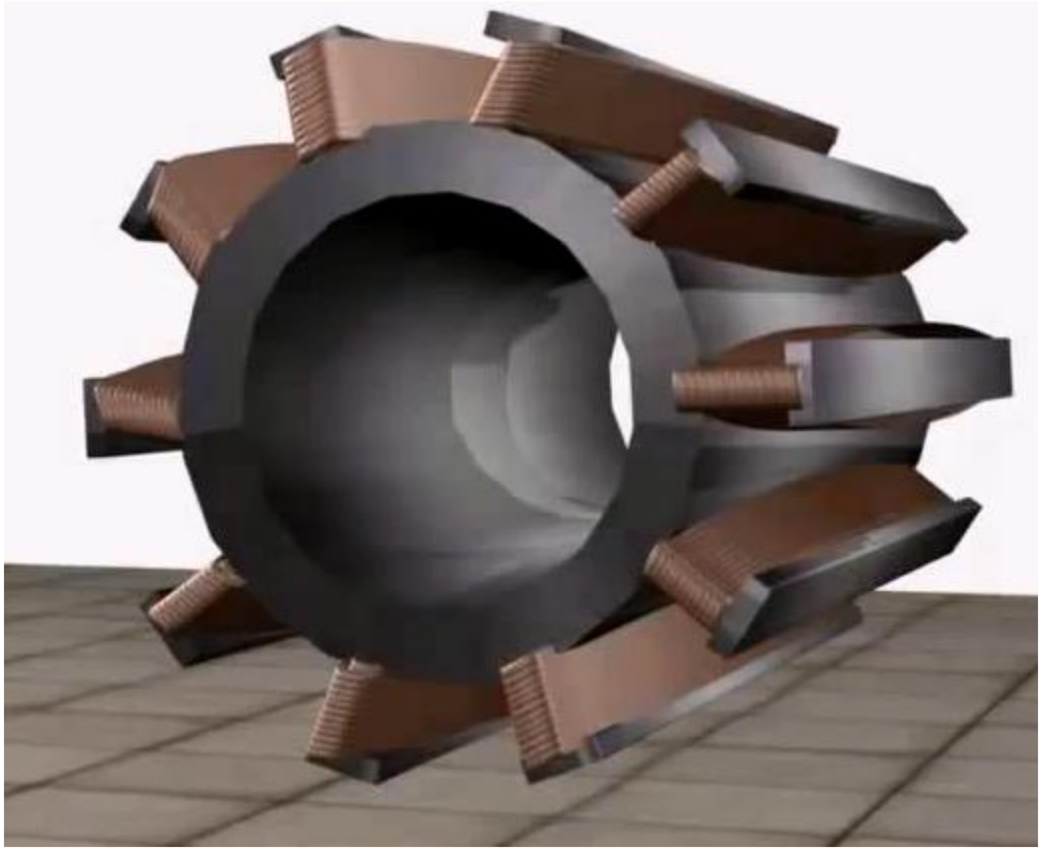
CONSTRUCTION OF DC MOTOR

Stator

- The stator is the stationary part of the motor.
- It sometimes includes the motor casing as well.
- Stator is basically electromagnet with adjacent poles having opposite polarity.
- They perform the function of producing magnetic field..

CONSTRUCTION OF DC MOTOR

Armature



CONSTRUCTION OF DC MOTOR

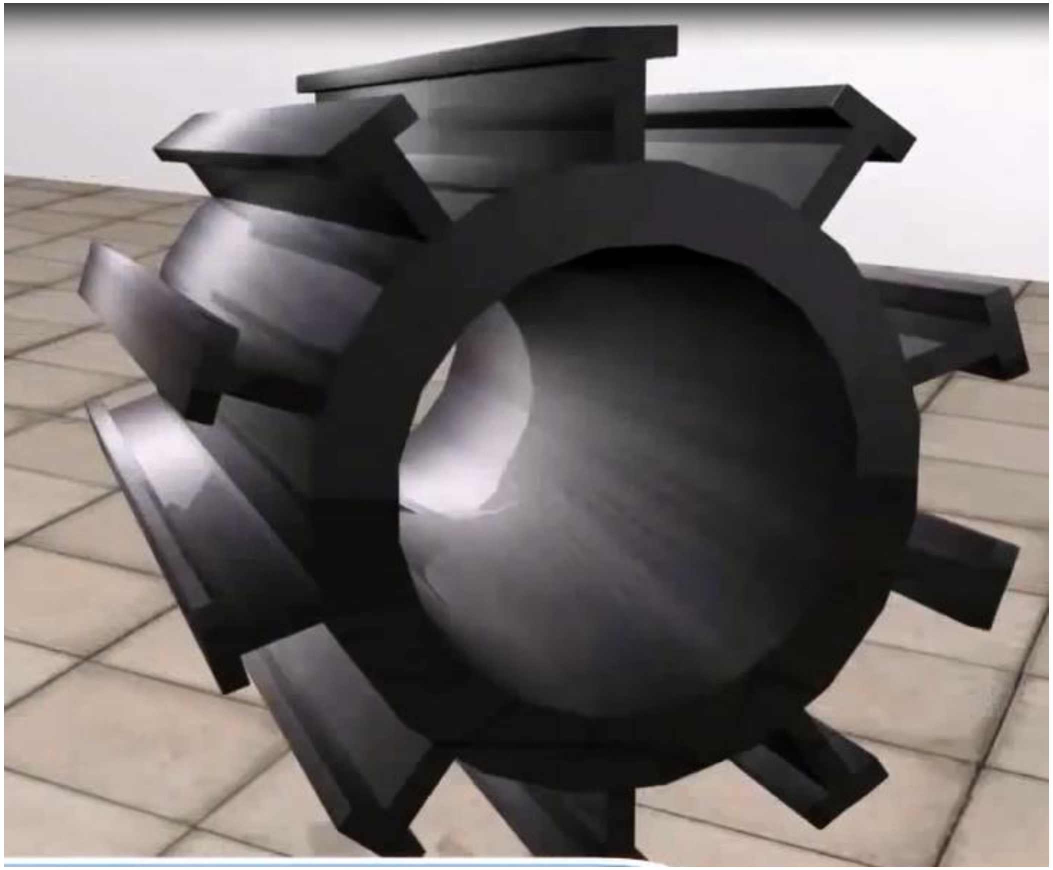
Armature

- The armature is mounted on a shaft.
- It is a system of conductors which is free to rotate on the supported bearing.
- The rotor (together with the axle and attached commutator) rotate with respect to the stator.
- The rotor consists of windings (generally on a core).
- The windings is electrically connected to the commutator

CONSTRUCTION OF DC MOTOR

Armature core

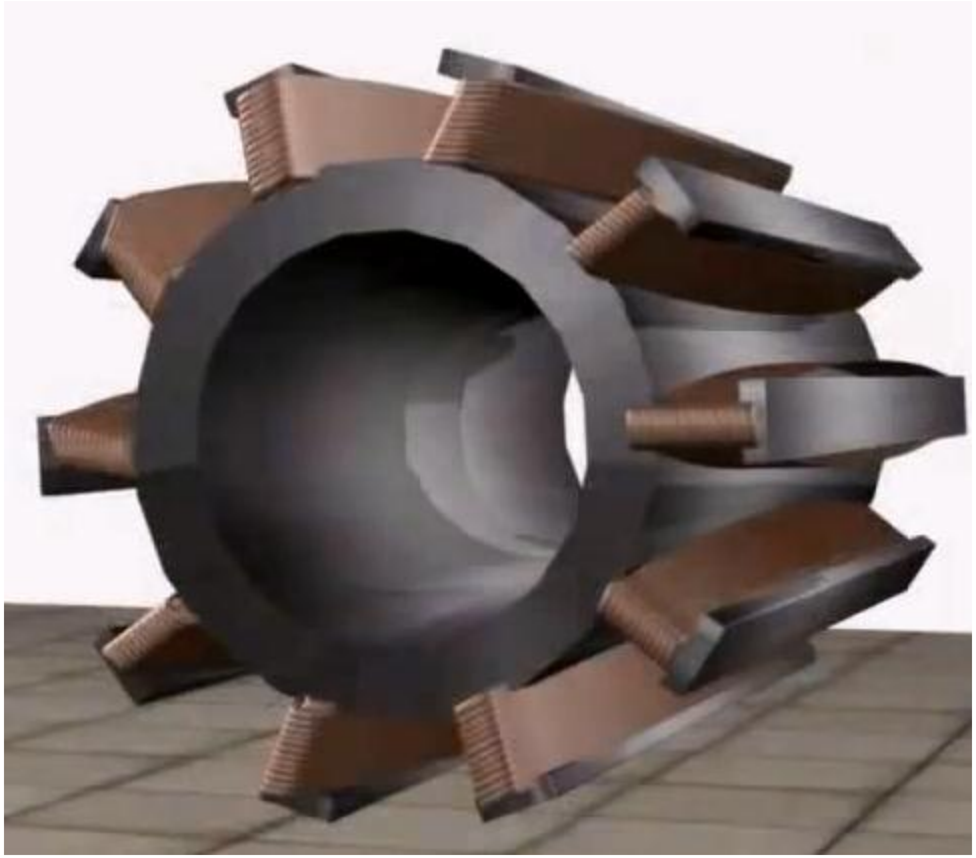
- Made from high permeable silicon-steel of higher grade.
- Stamping operation.
- Each lamination is about 0.6 mm thick.
- Laminations are separated by thin coating of varnish as insulation.



- Laminations cut the path of eddy current into several units.
- The direction of laminations are perpendicular to the path of eddy current and parallel to the flux.

CONSTRUCTION OF DC MOTOR

Armature winding

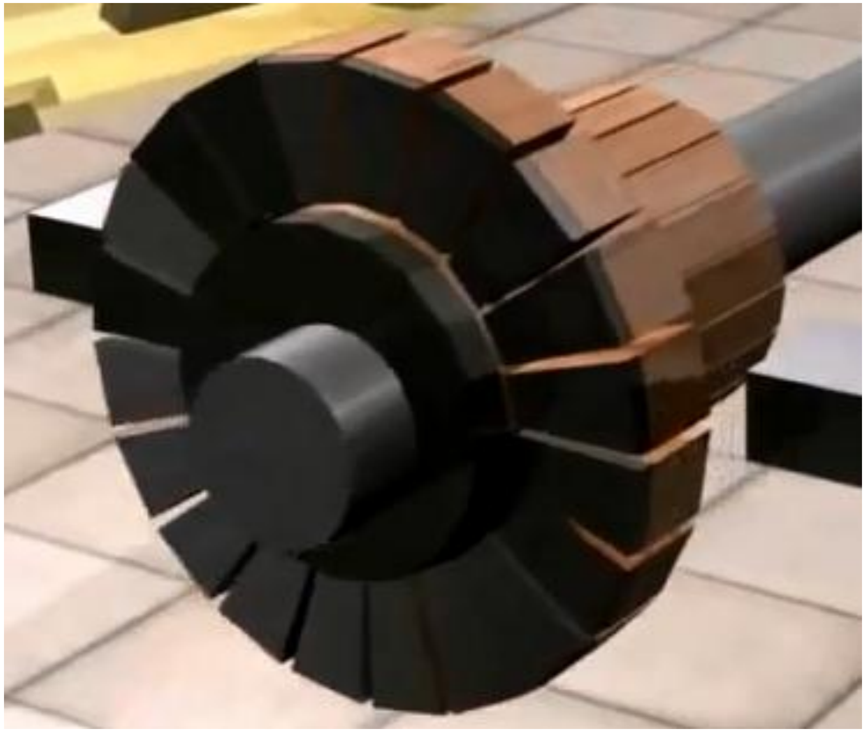


- At the outer periphery of the core has slots to carry armature windings.

CONSTRUCTION OF DC MOTOR

Commutator

- Cylindrical in shape
- Made of copper and more recently, graphite.
- The number of commutator segments is equal to the number of conductor slots in the armature.
- Performs two basic functions:
  - To provide electrical connections between stationary electrical circuit (say battery) and conductor.
  - To perform the switching action reversing the electrical connections between electrical circuit and conductor.

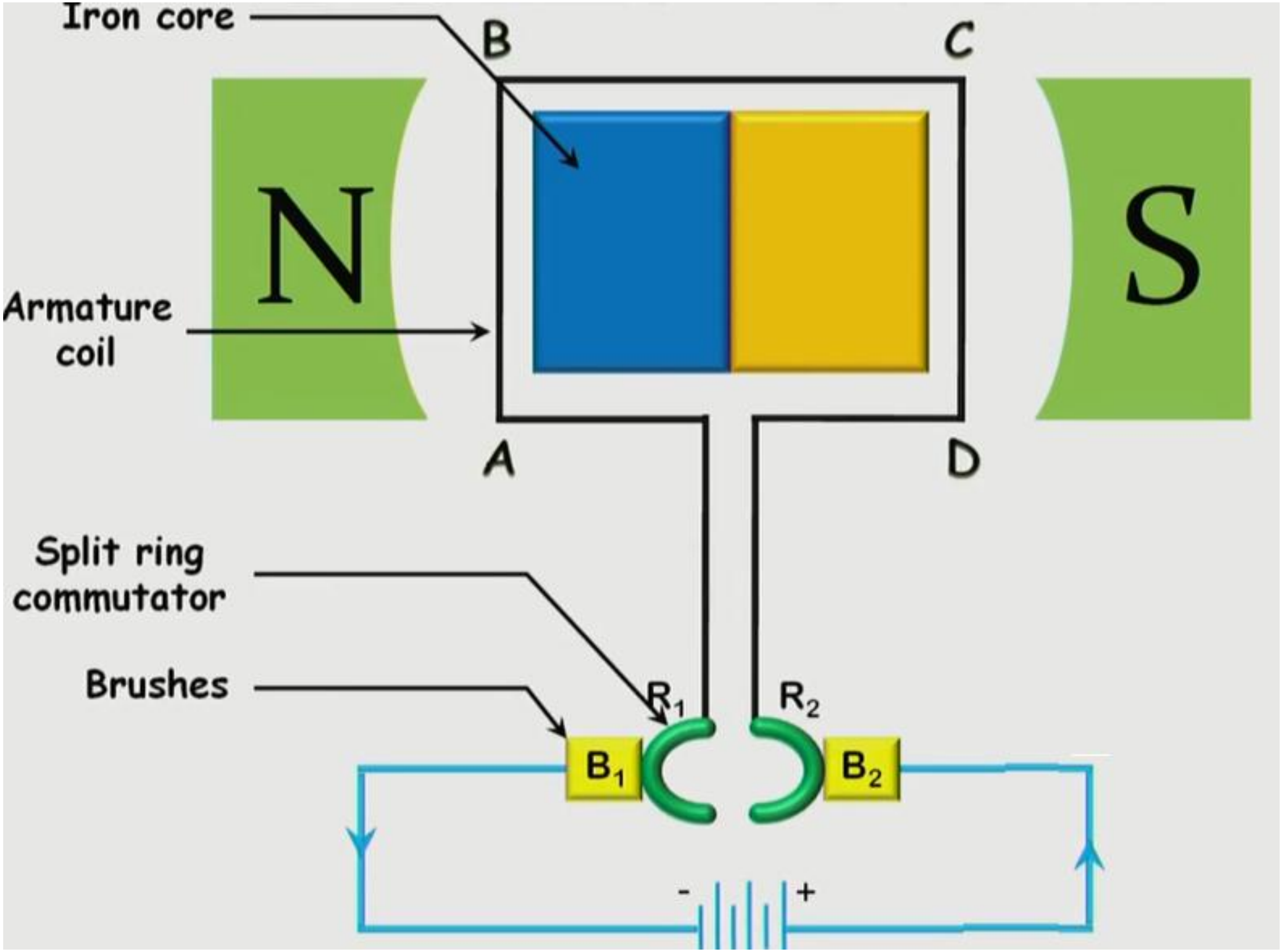


CONSTRUCTION OF DC MOTOR

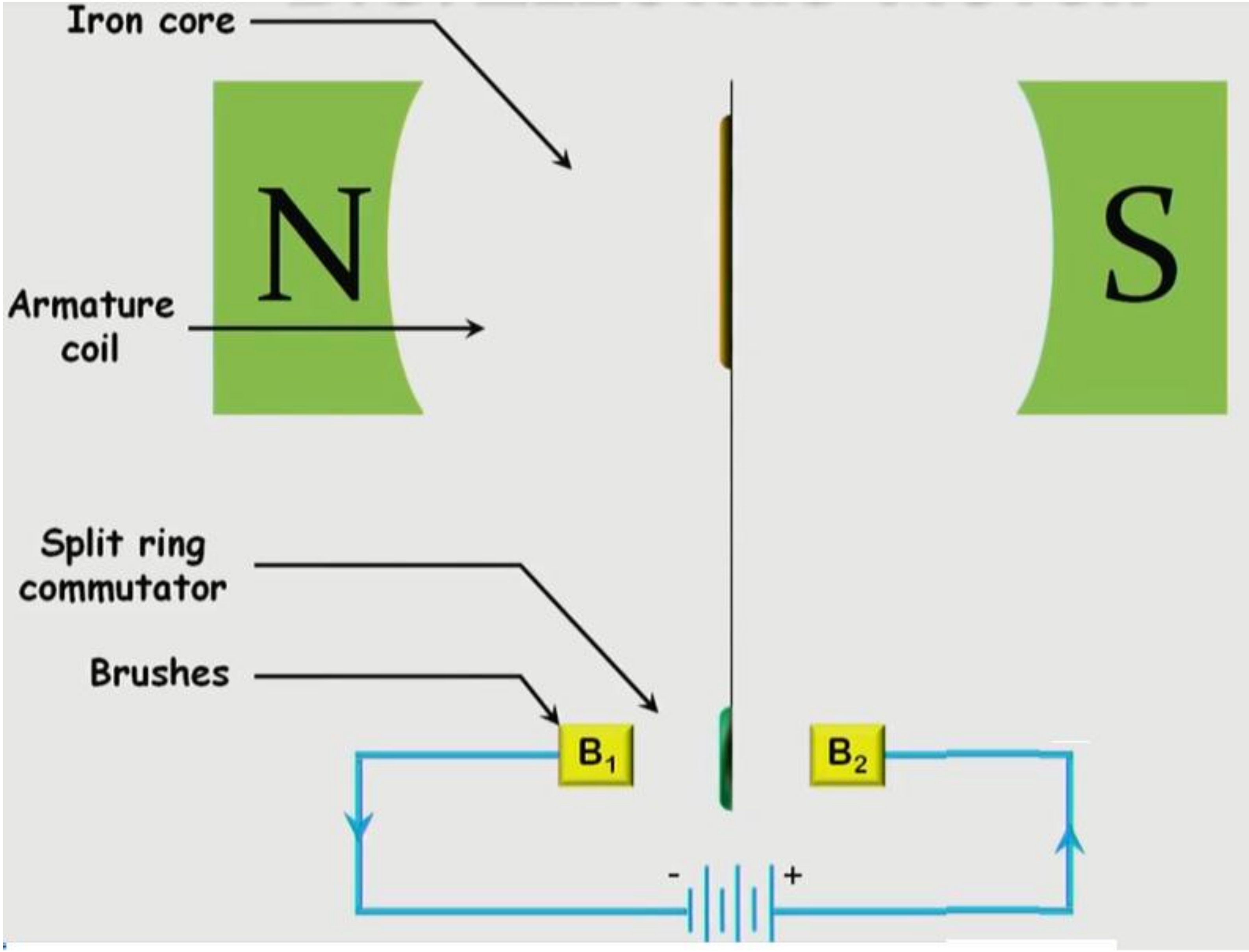
Commutator

- This component comes in contact with the brush to allow current to flow through the armature and is responsible for the direction of the current to shift as it spins and slides in contact with the brushes.

CONSTRUCTION OF DC MOTOR



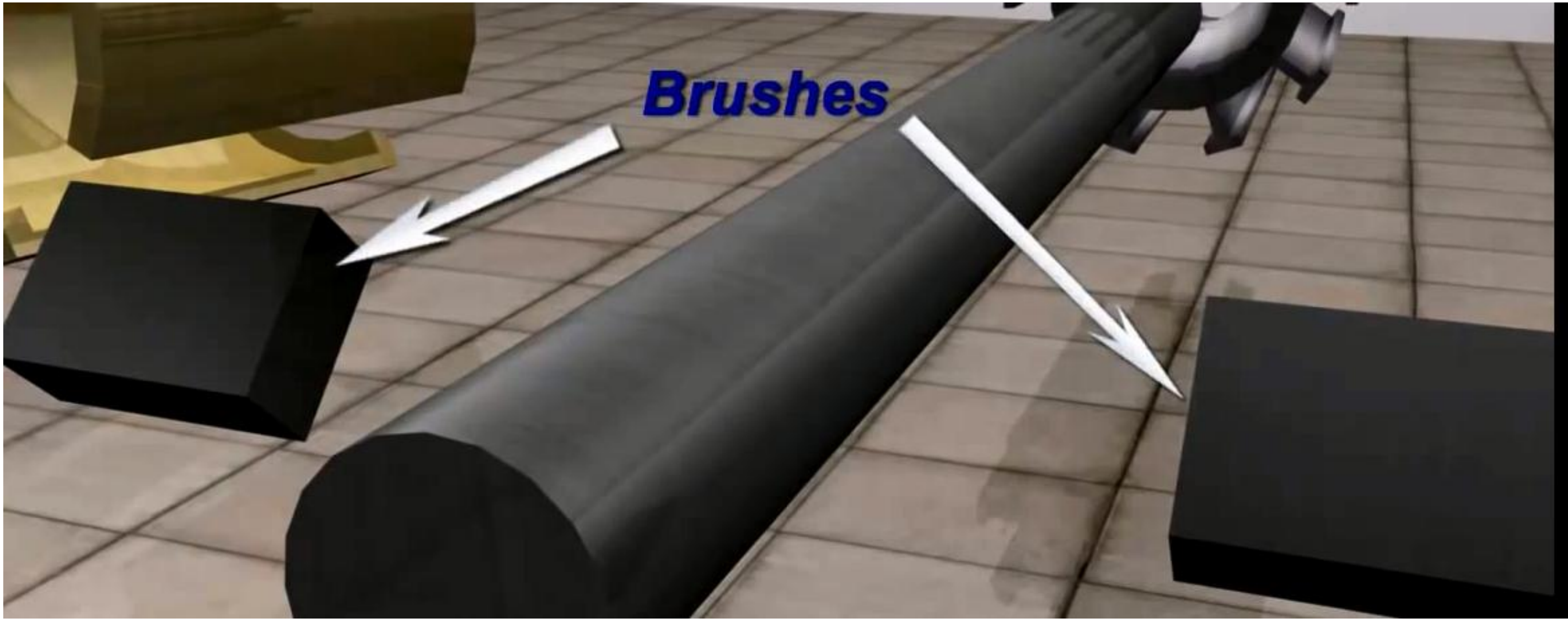
CONSTRUCTION OF DC MOTOR



CONSTRUCTION OF DC MOTOR

Brushes

- Function of brushes is to collect current from moving commutator.
- The current is supplied to the armature.

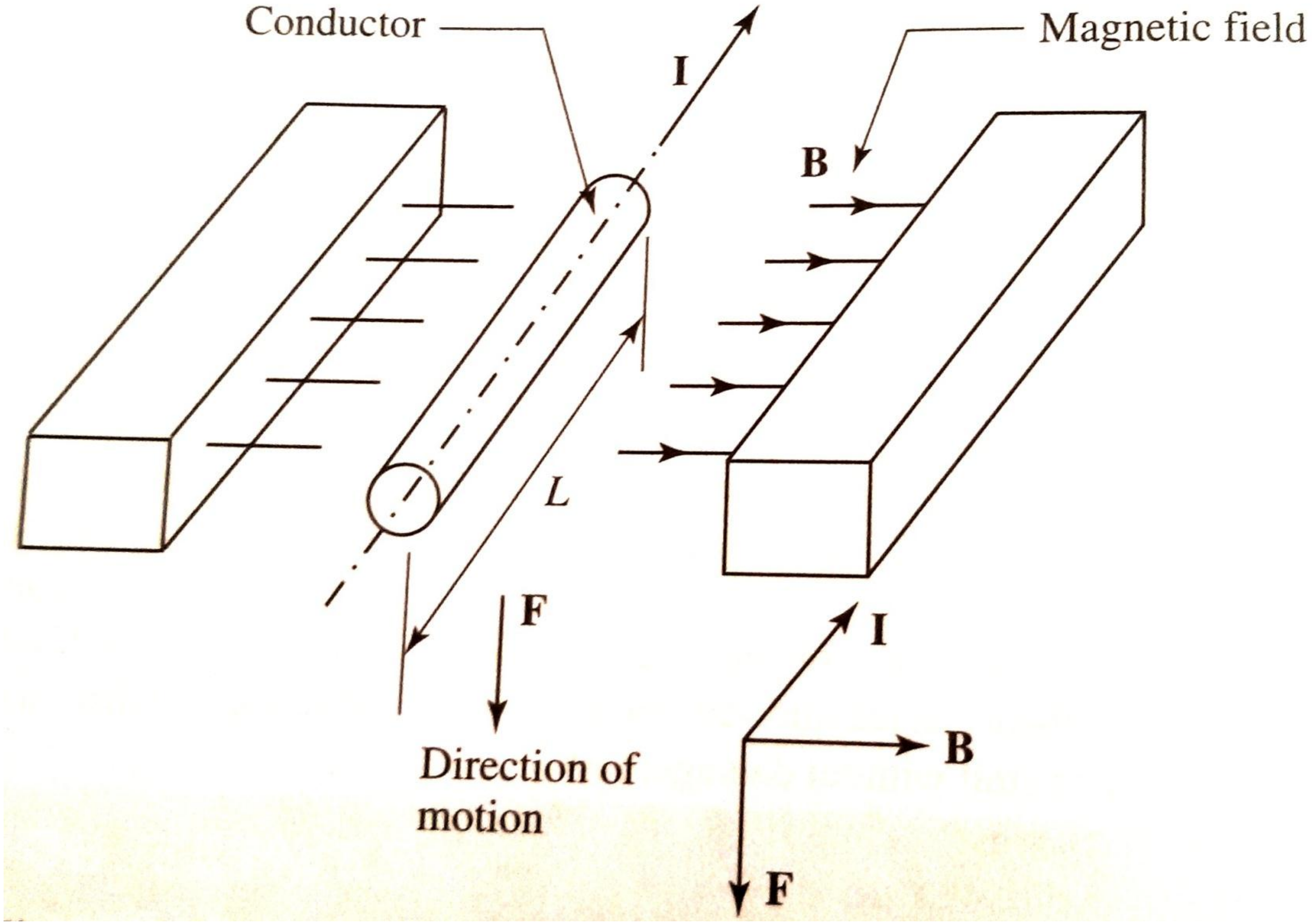


PRINCIPLE OF OPERATION OF A DC MOTOR

Any electric motor works on the principle that follows Amphere’s law:

It states that : A conductor of length L will experience a force F if an electric current I flows through that conductor at right angle to a magnetic field having a flux density B.

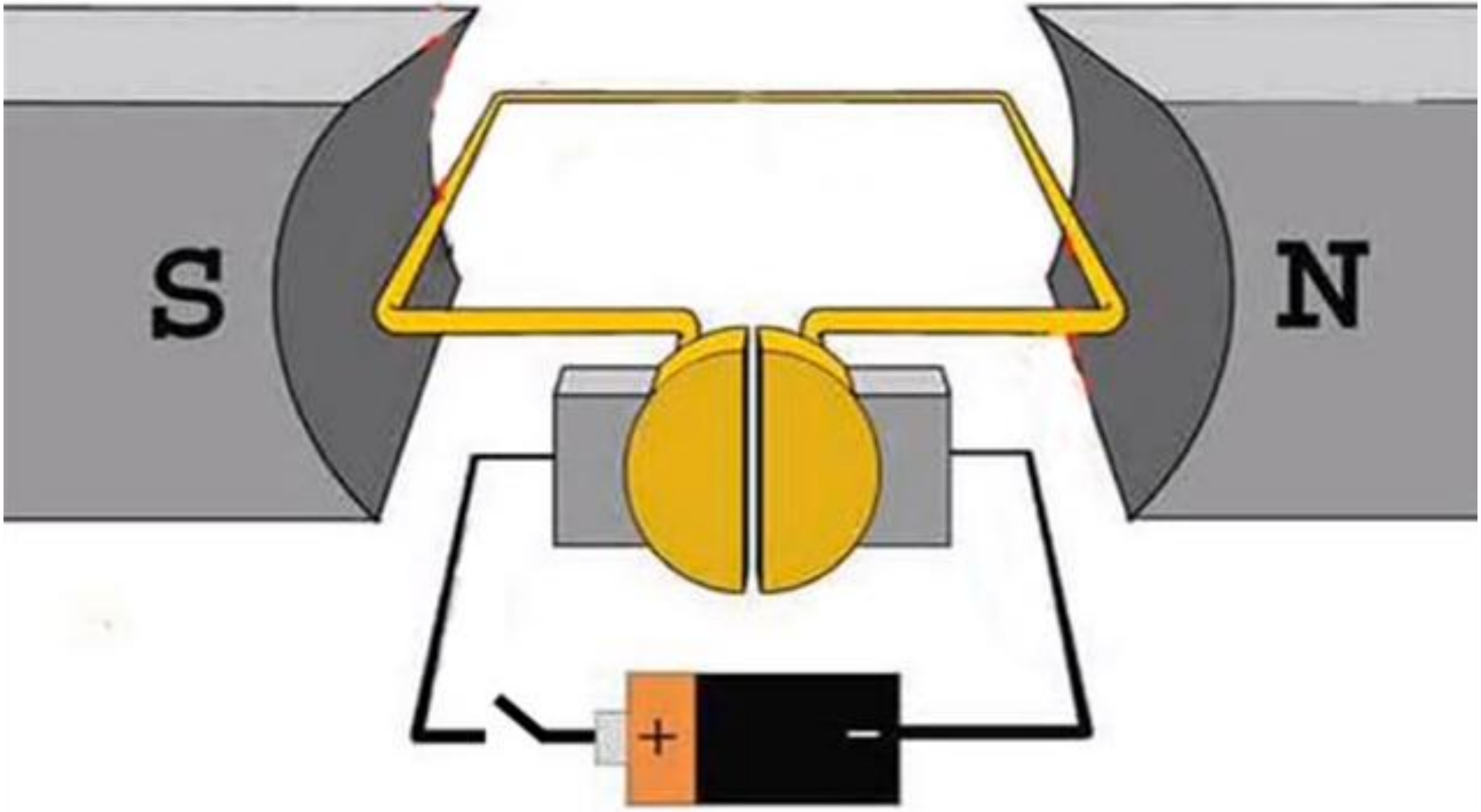
PRINCIPLE OF OPERATION OF A DC MOTOR



Thus, F = (BxI) L = BIL sin Θ

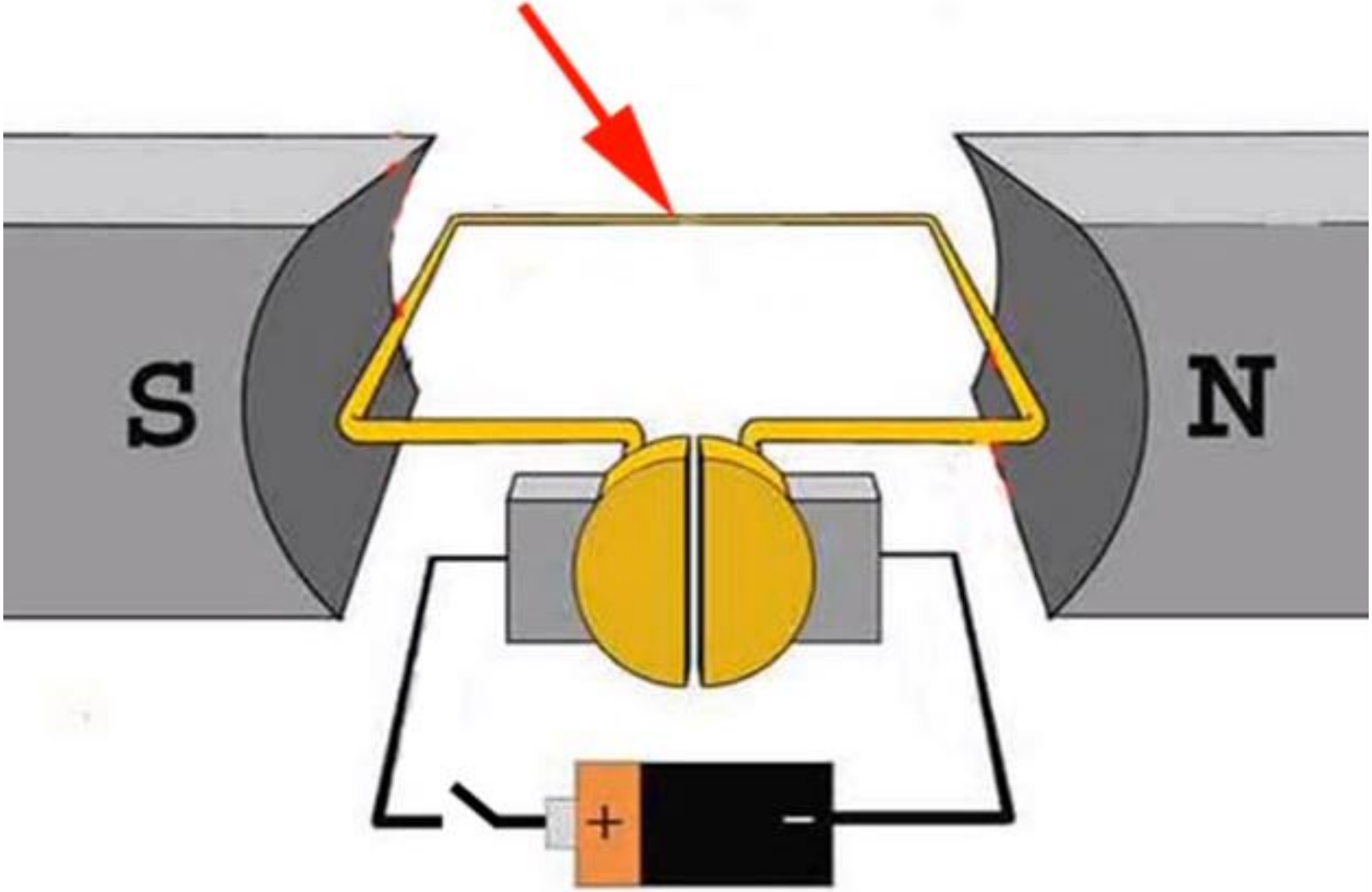
Where, Θ = angle between the current flow and the magnetic flux density.

PRINCIPLE OF OPERATION OF A DC MOTOR



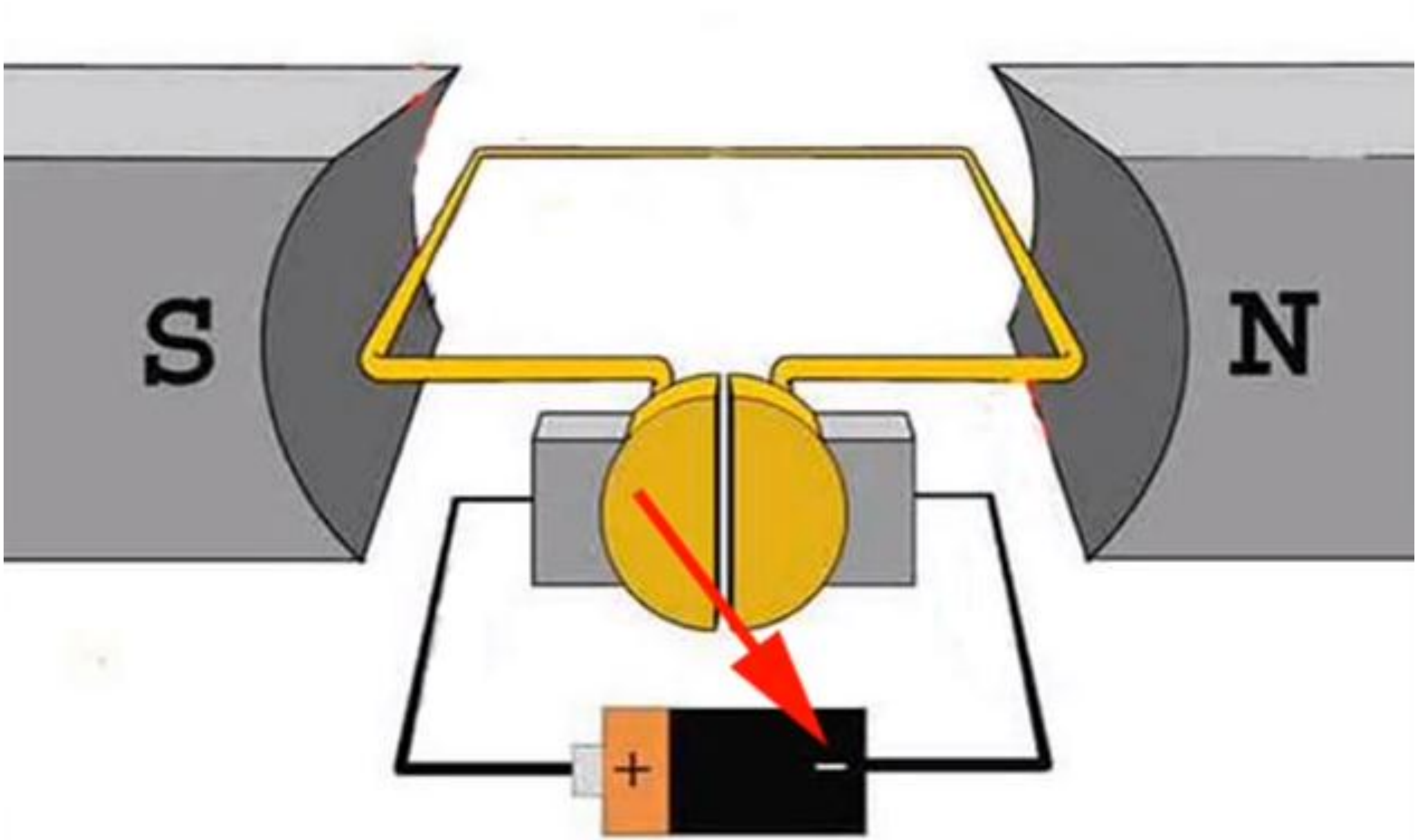
A DC motor model

PRINCIPLE OF OPERATION OF A DC MOTOR



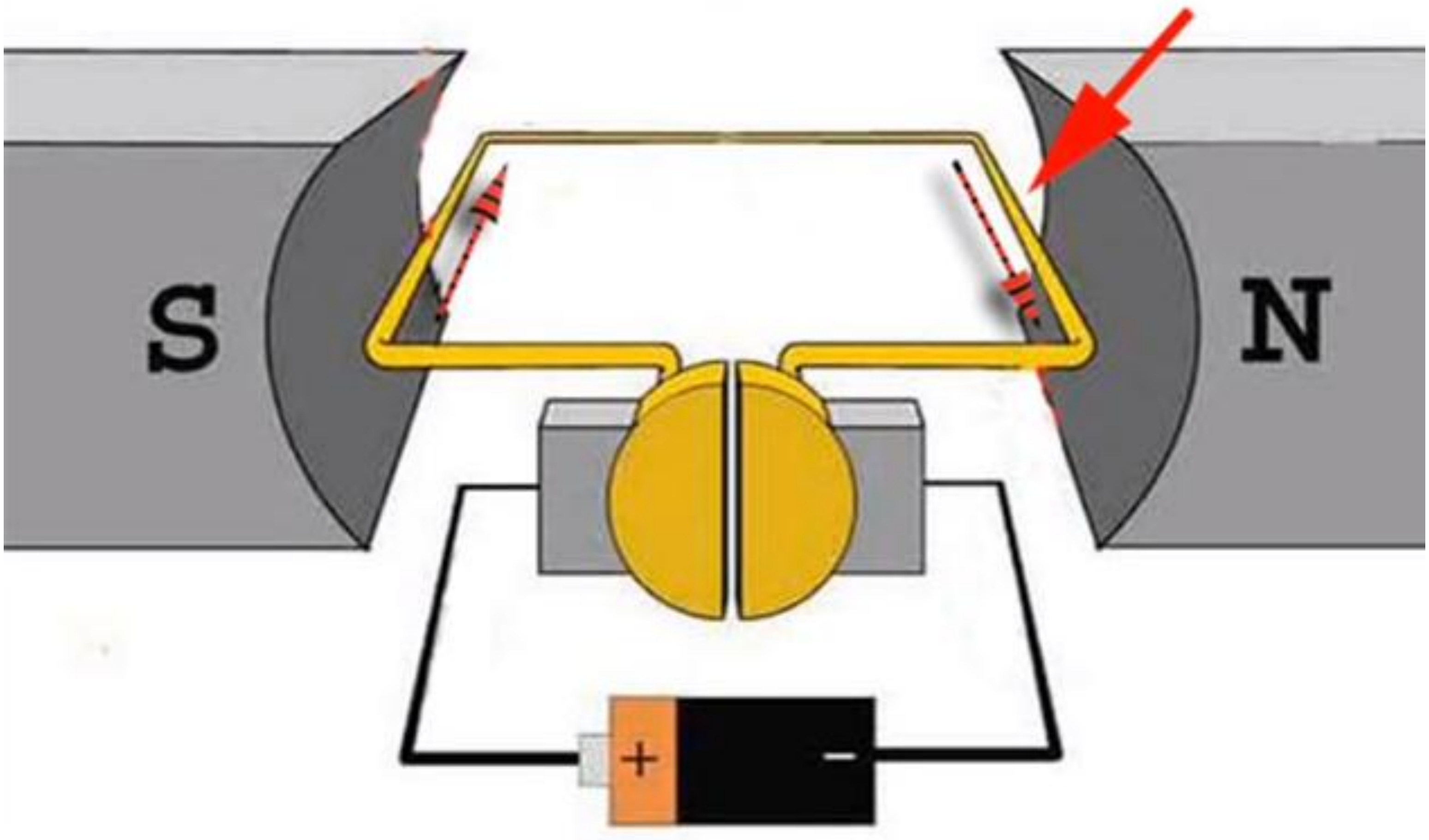
One single turn of conductor is placed between two opposite poles

PRINCIPLE OF OPERATION OF A DC MOTOR



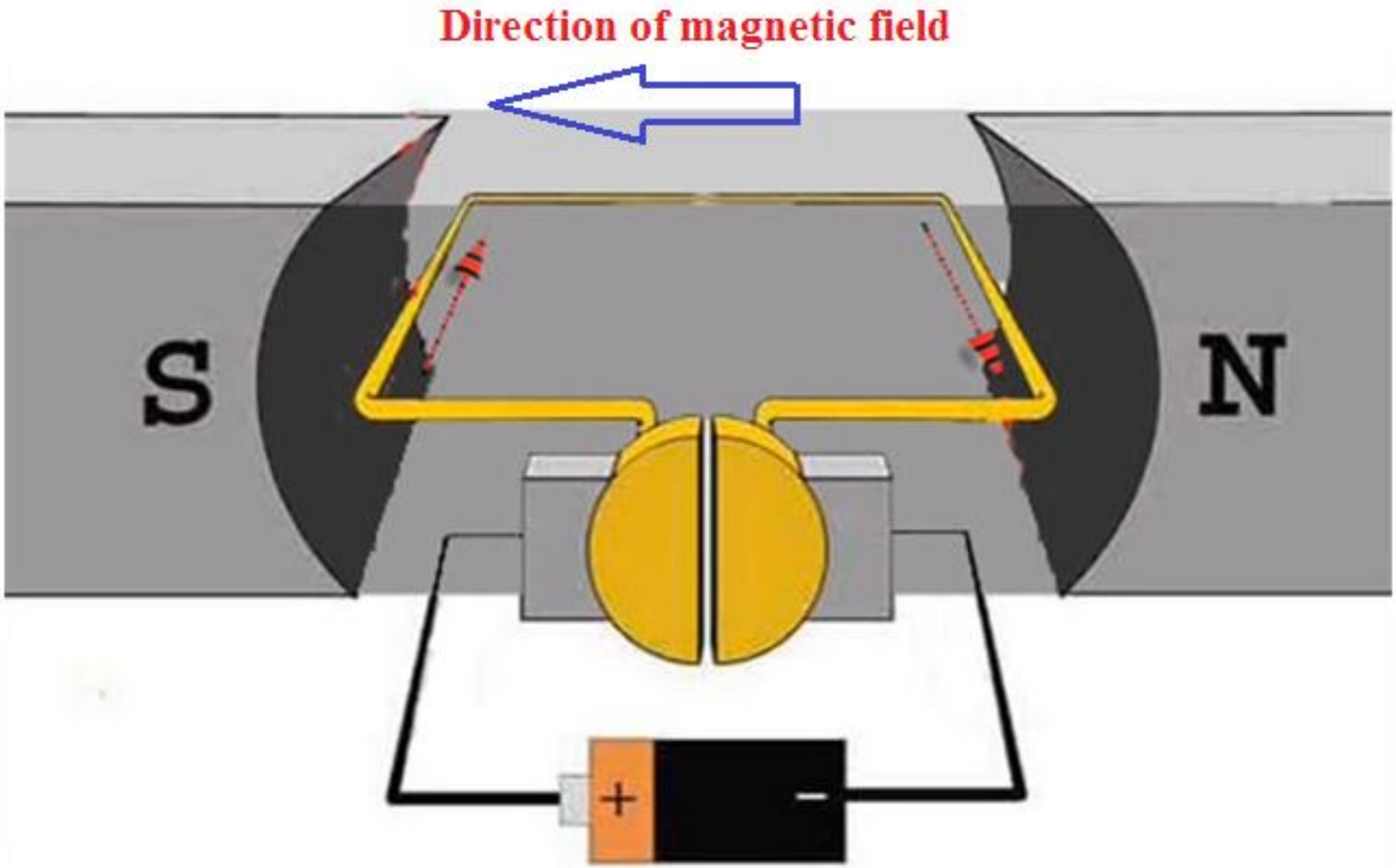
- If we start supply of DC through a commutator to a single turn, electric current starts to flow.
- +ve is connected to S pole. (Placed at left side)
- -ve is connected to N pole. (Placed at right side)

PRINCIPLE OF OPERATION OF A DC MOTOR



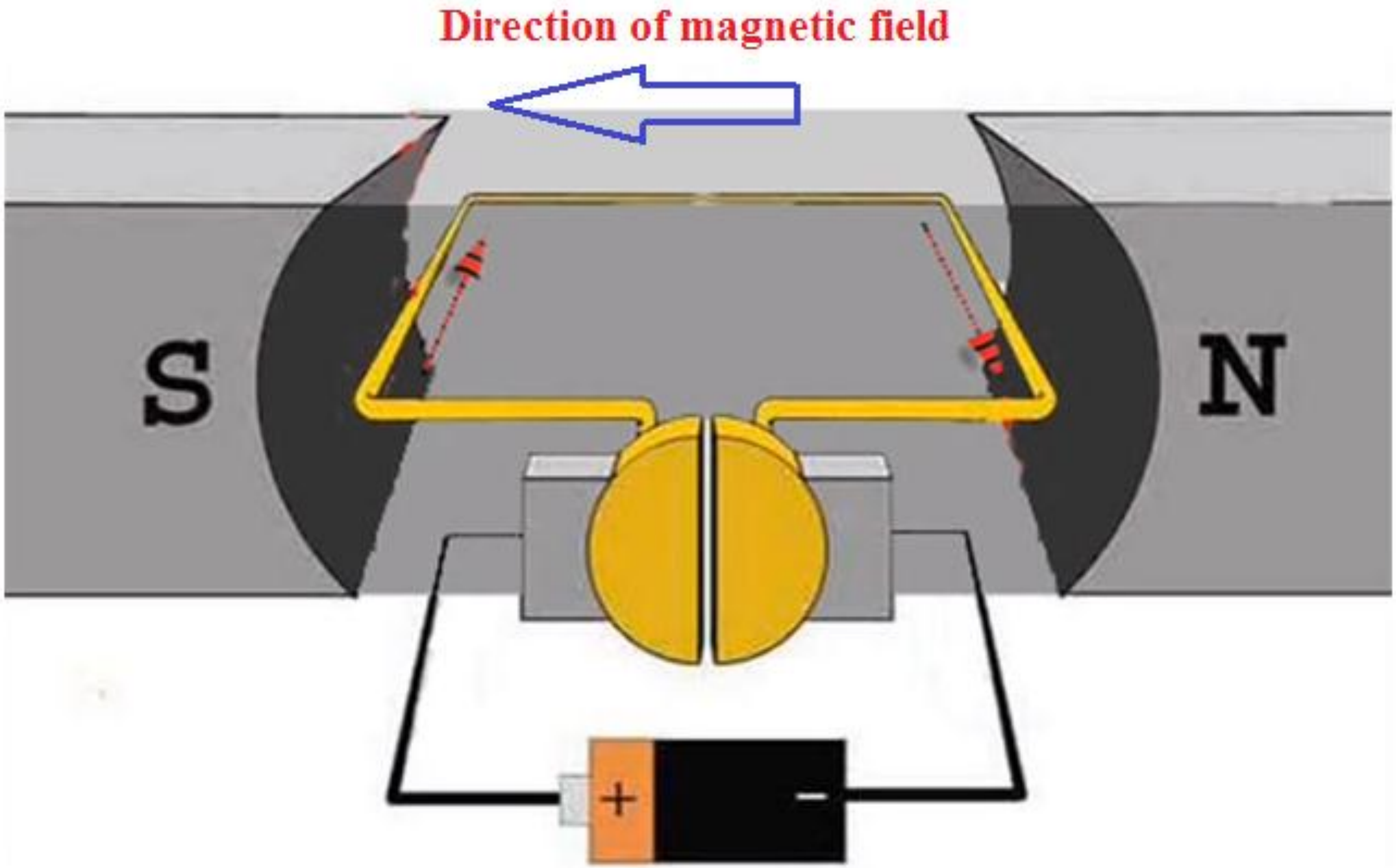
- Current in left side conductor flows inwards.
- Current in right side conductor flows outwards.

PRINCIPLE OF OPERATION OF A DC MOTOR



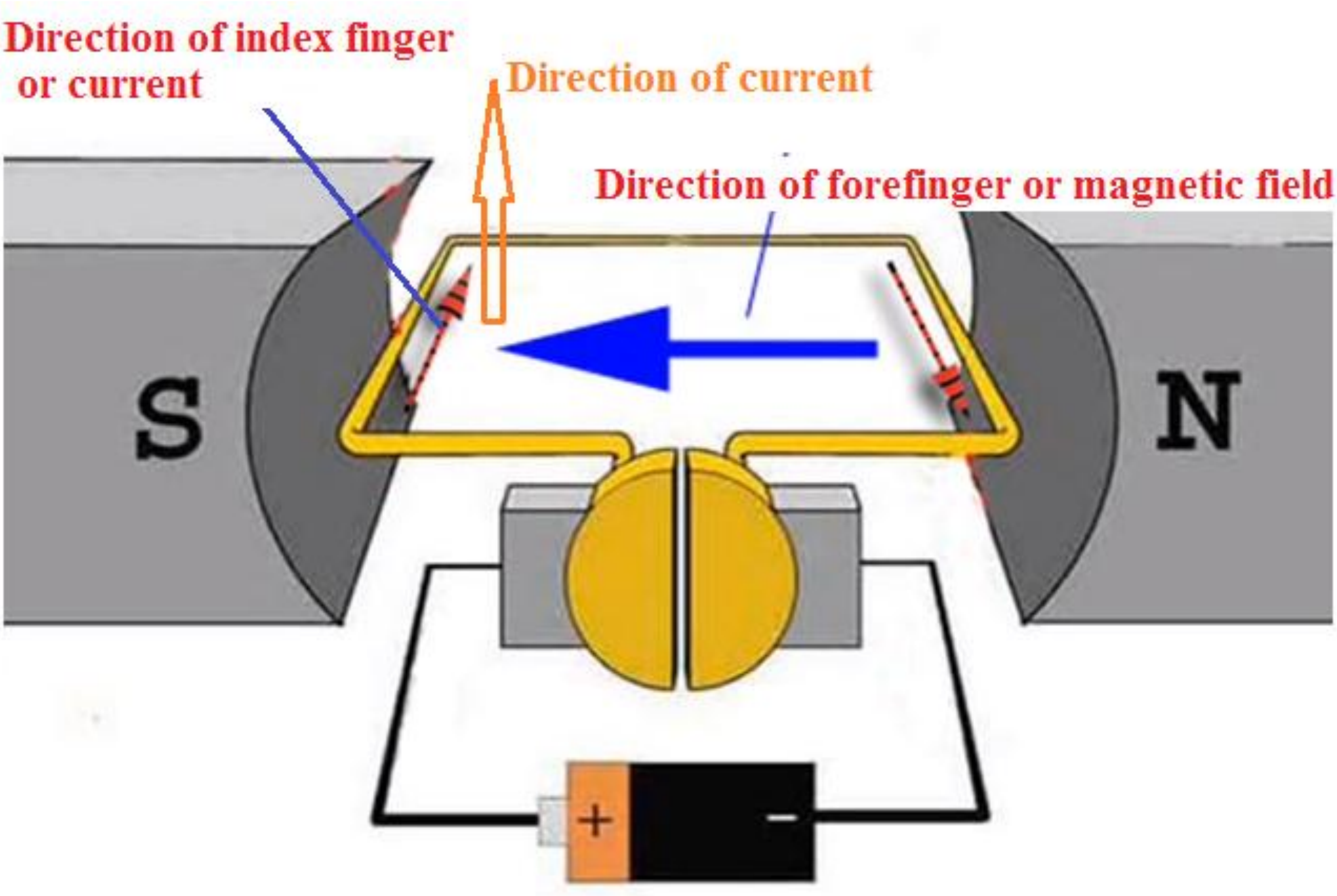
- Conductors are carrying current and placed inside magnetic field.
- Both conductors can experience Mechanical force acting on them.

PRINCIPLE OF OPERATION OF A DC MOTOR



- Direction of mechanical force can be determined by applying Flemings left hand rule

PRINCIPLE OF OPERATION OF A DC MOTOR



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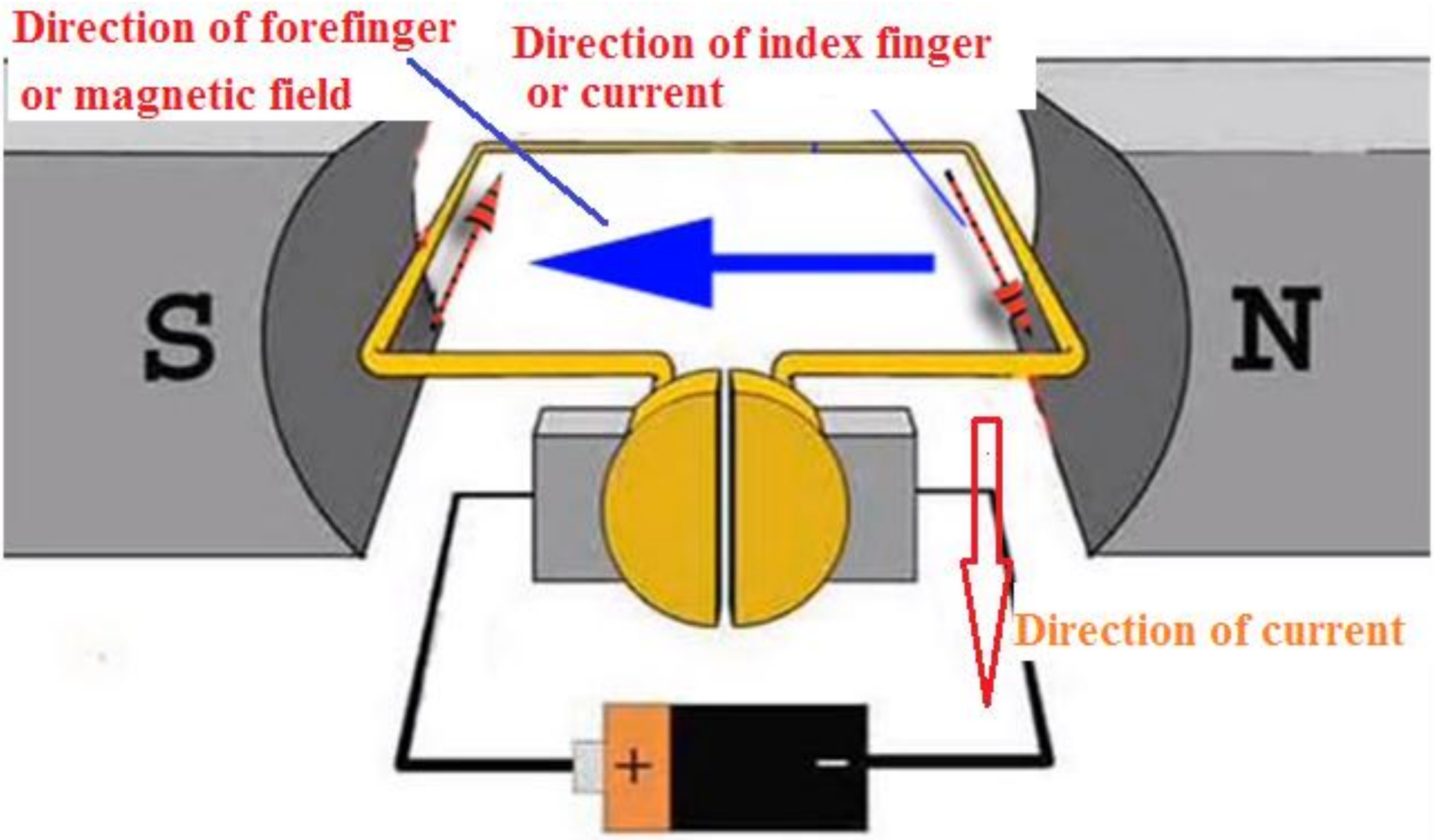

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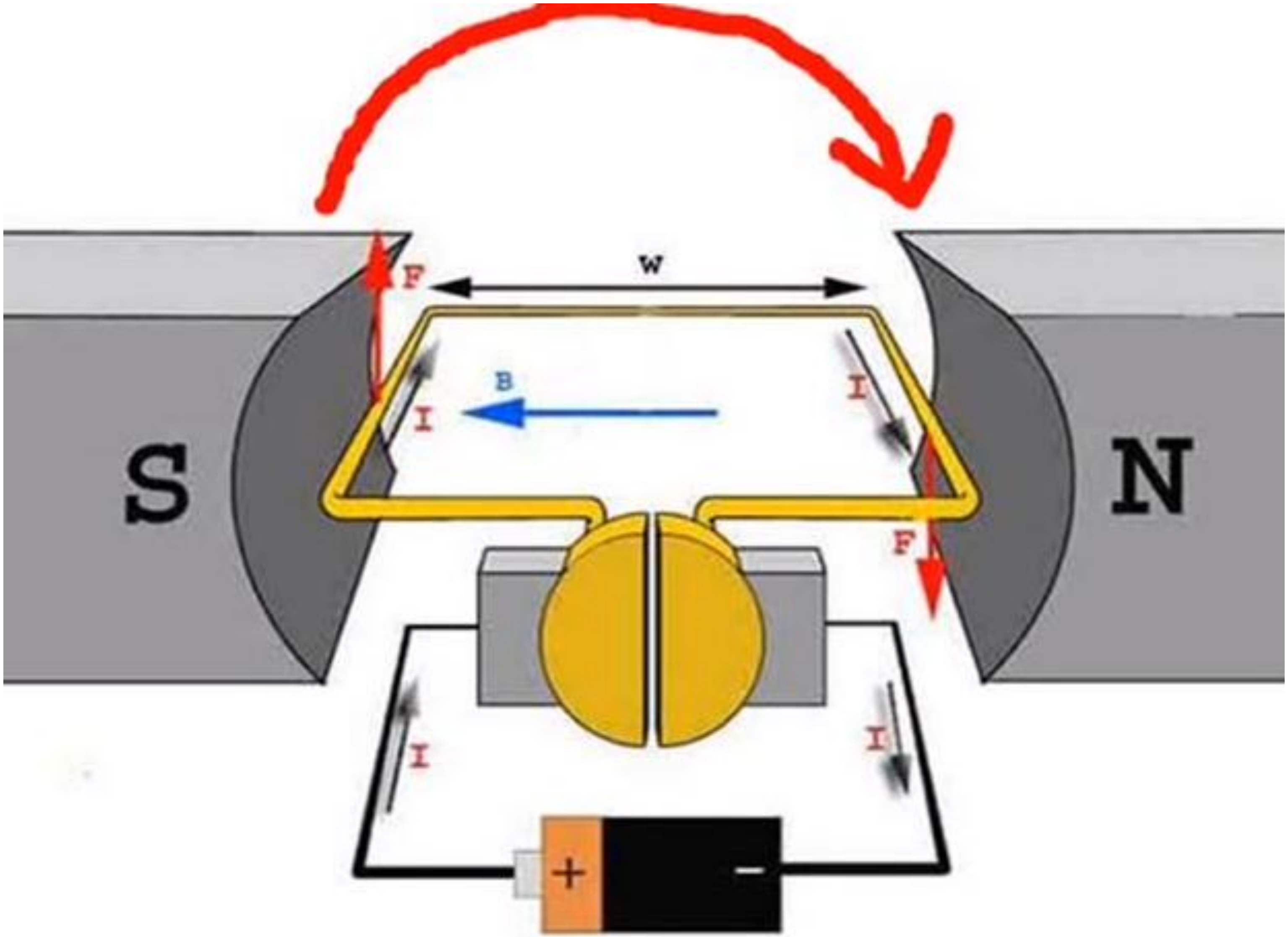
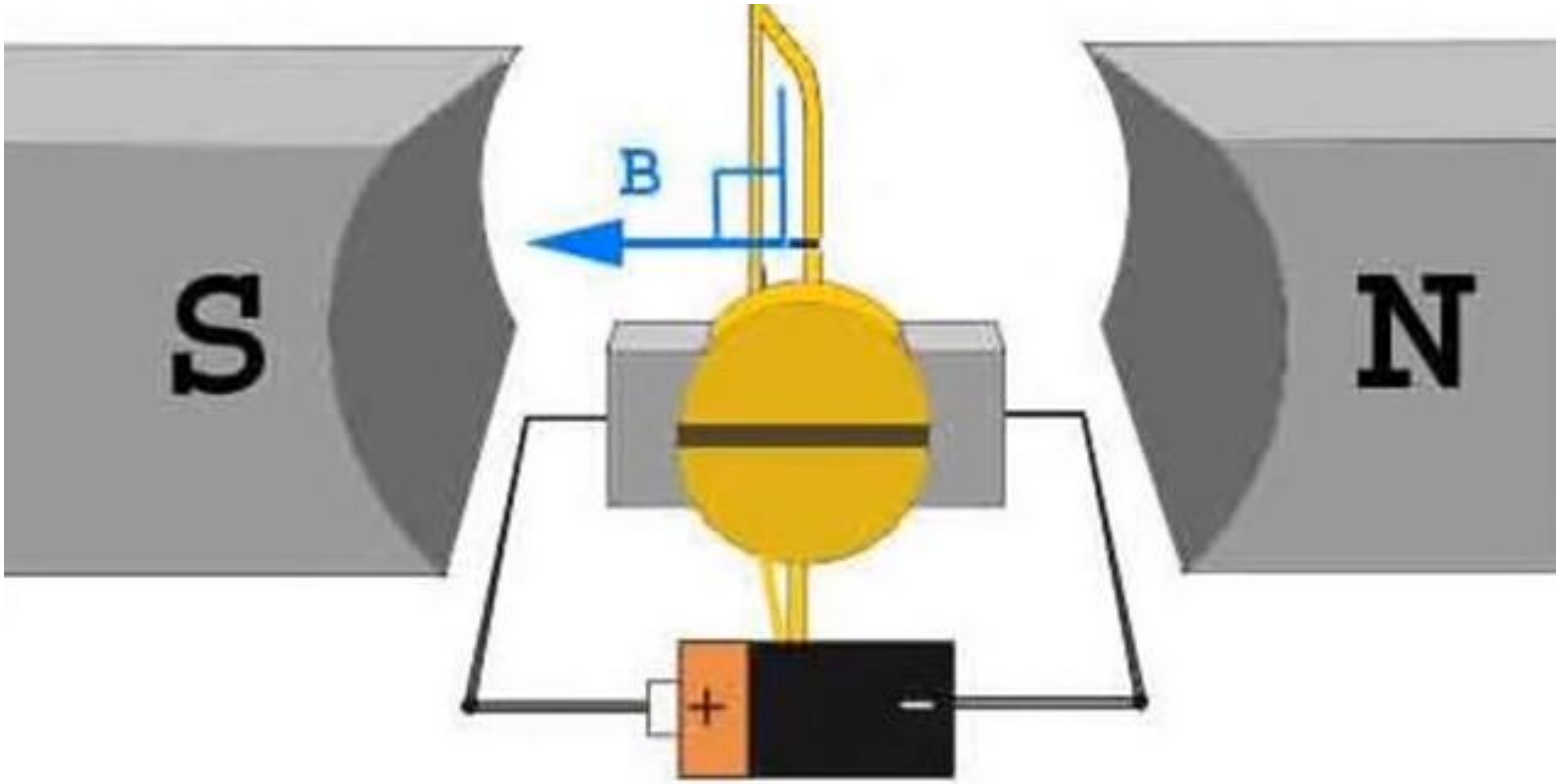


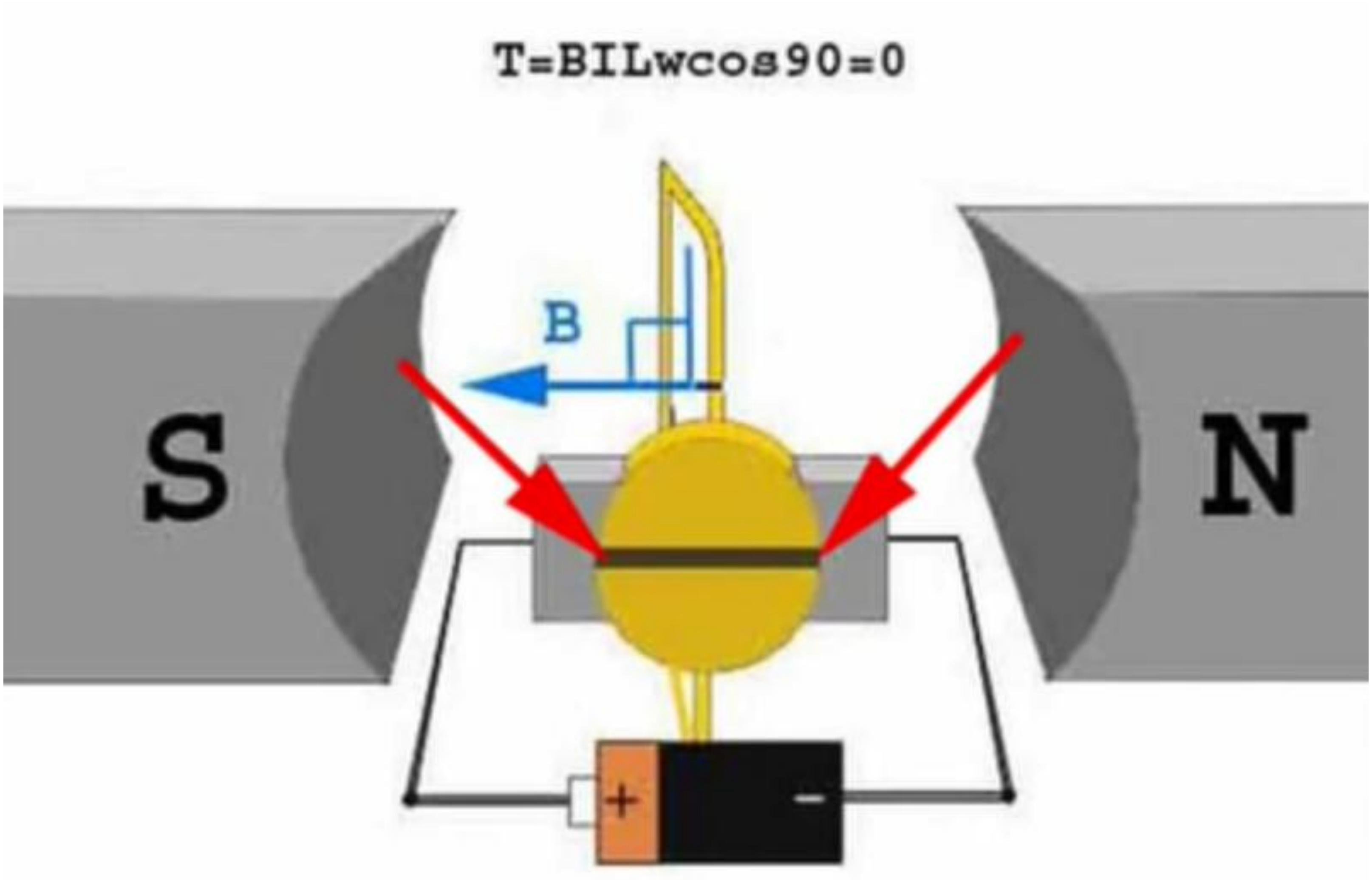
Torque is produced due to upwards and downwards forces.
It rotates the conductor in CW direction.

PRINCIPLE OF OPERATION OF A DC MOTOR



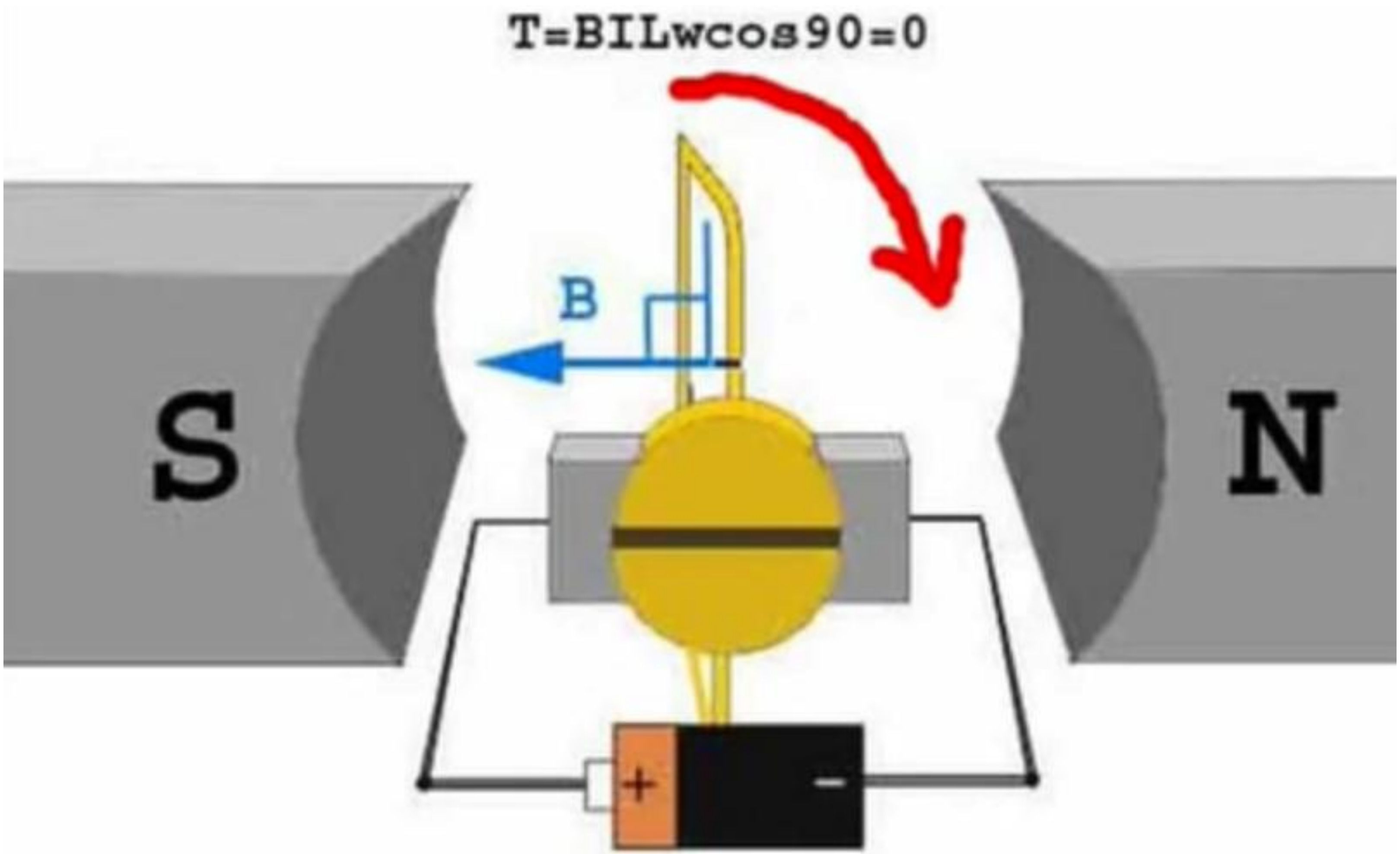
- After 90 CW rotation the turn comes in vertical position and current stops to flow.
- This is irrespective to the magnetic field.

PRINCIPLE OF OPERATION OF A DC MOTOR



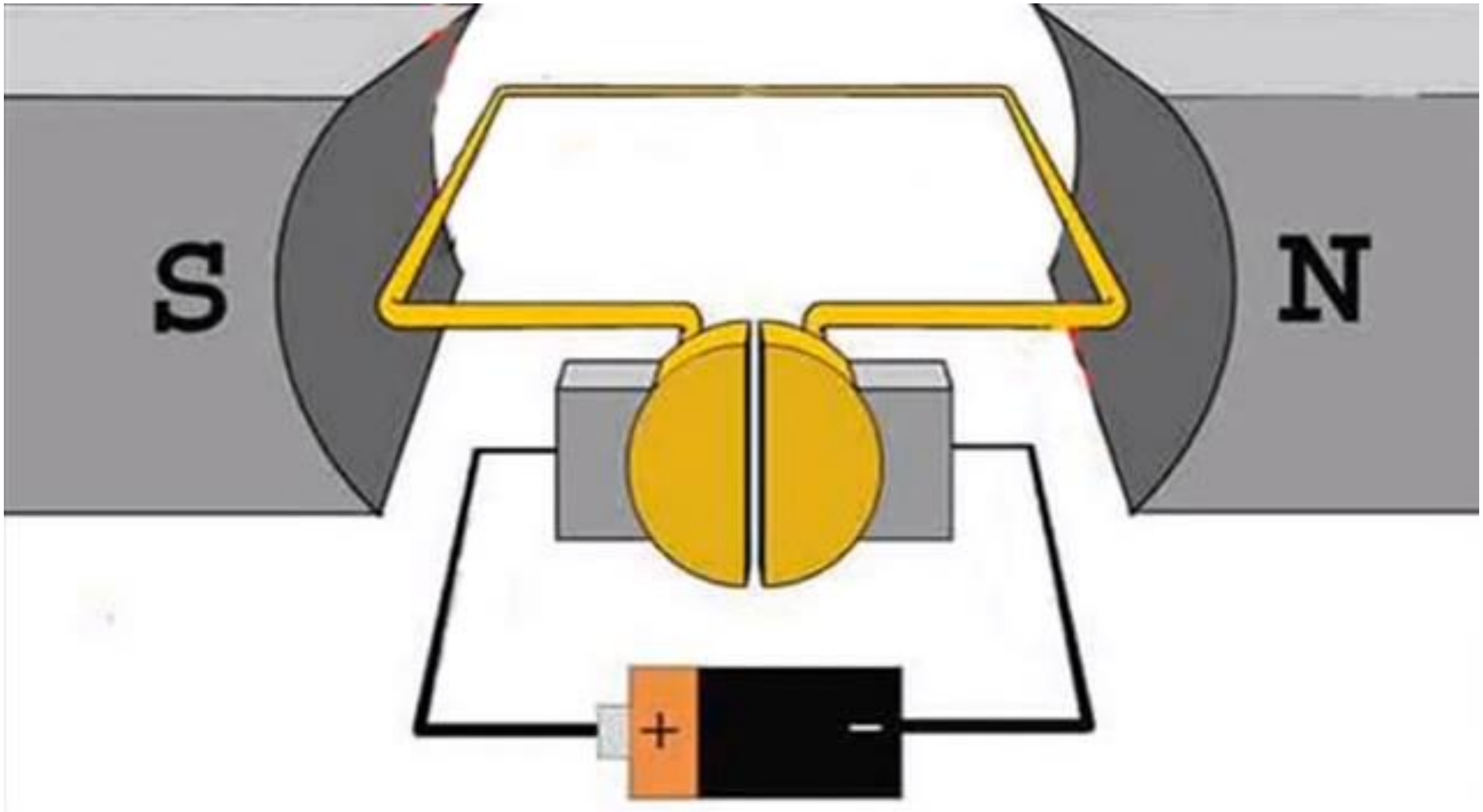
- The current stops to flow as conductor and brushes rest in between two commutator segments.

PRINCIPLE OF OPERATION OF A DC MOTOR



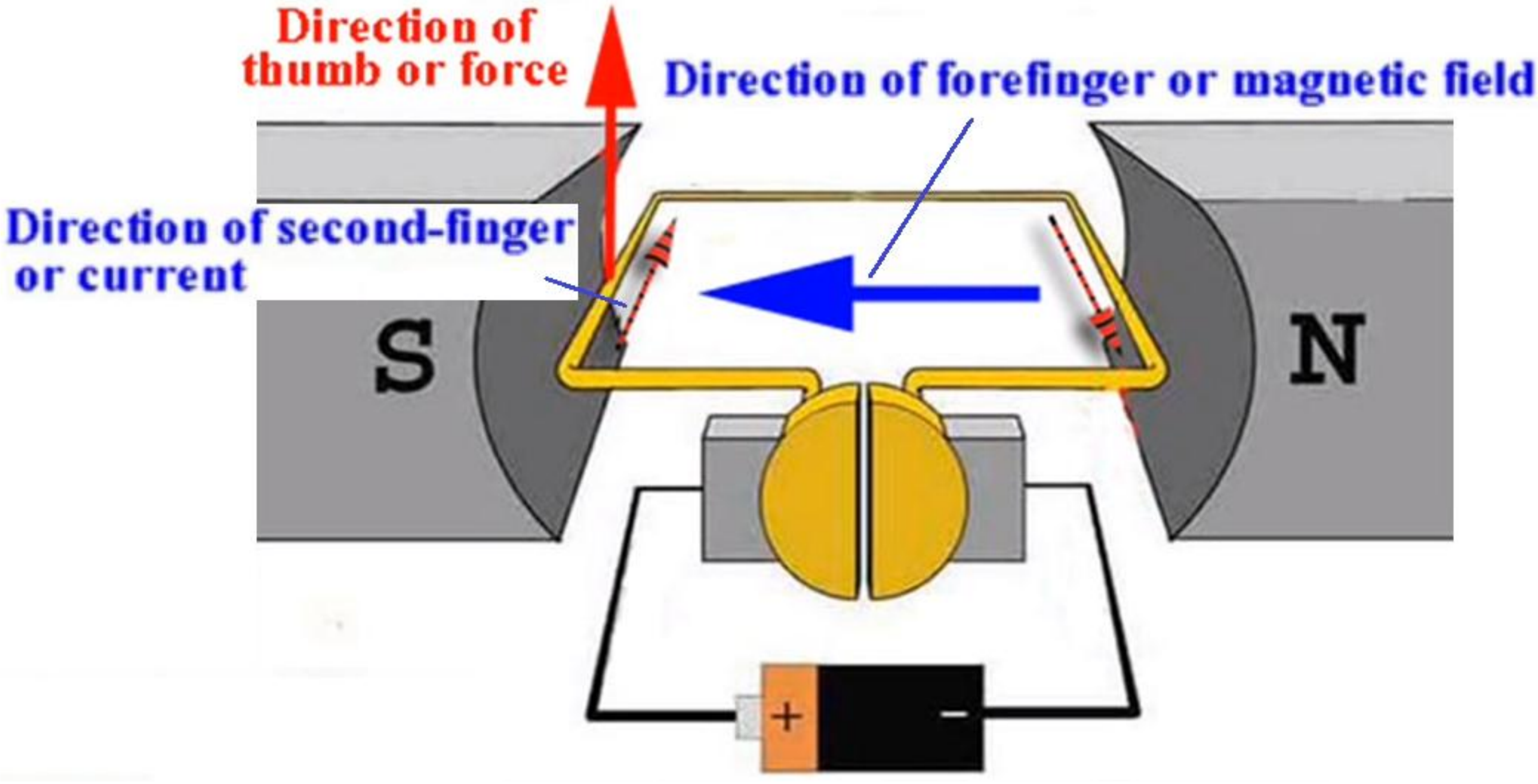
- Due to moment of inertia the turn continues to rotates and completes an angle of 180.

PRINCIPLE OF OPERATION OF A DC MOTOR



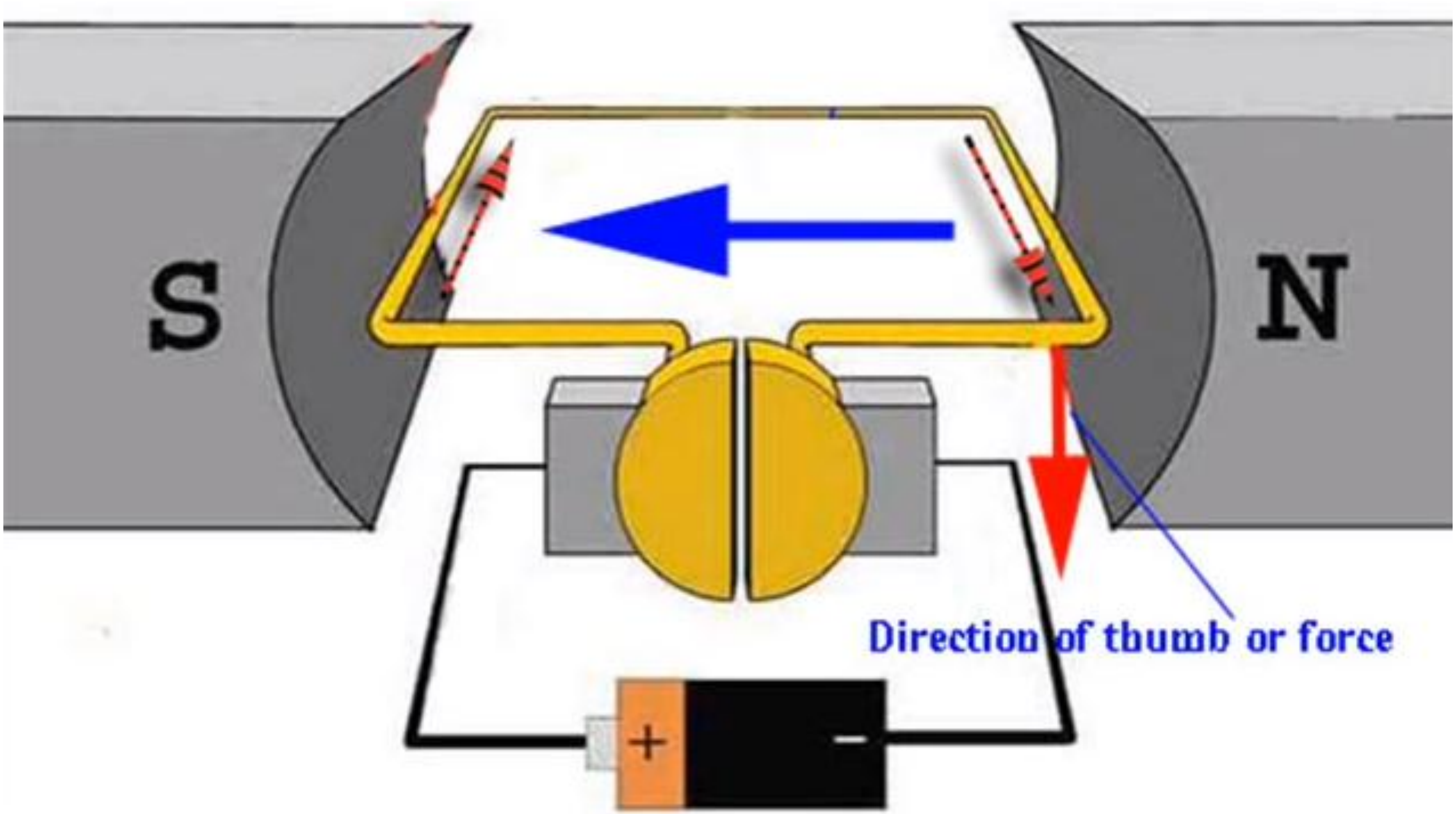
- Turn comes horizontal again, but position of conductor is reversed here.
- Conductor at left position comes to right and VV

PRINCIPLE OF OPERATION OF A DC MOTOR



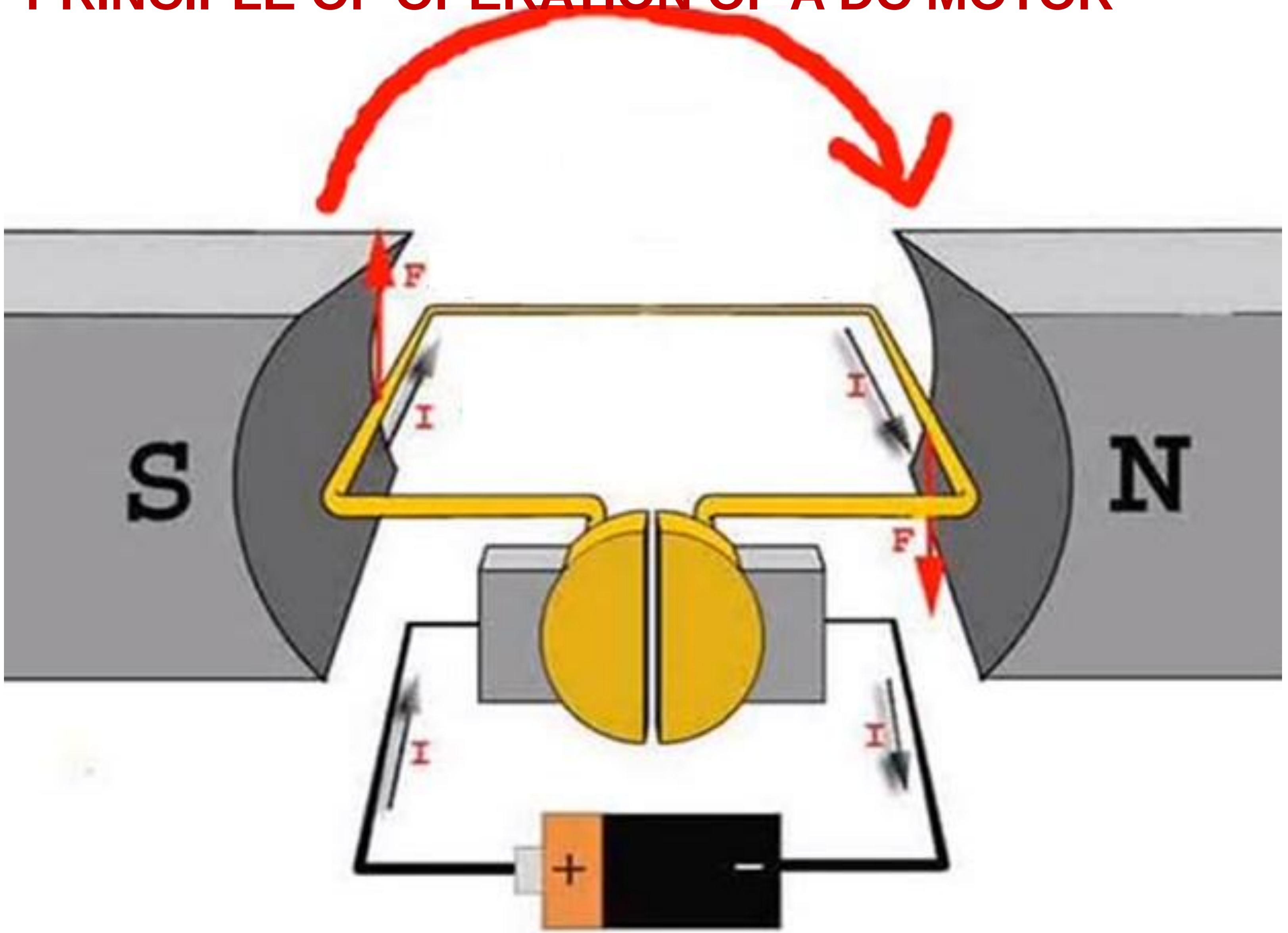
- Again mechanical force acts on conductor.
- At S position applying Flemings rule

PRINCIPLE OF OPERATION OF A DC MOTOR



- At N position applying Flemings rule
- If blue arrow indicates direction of forefinger or magnetic field
- If thin arrow indicates direction of second finger or current.

PRINCIPLE OF OPERATION OF A DC MOTOR

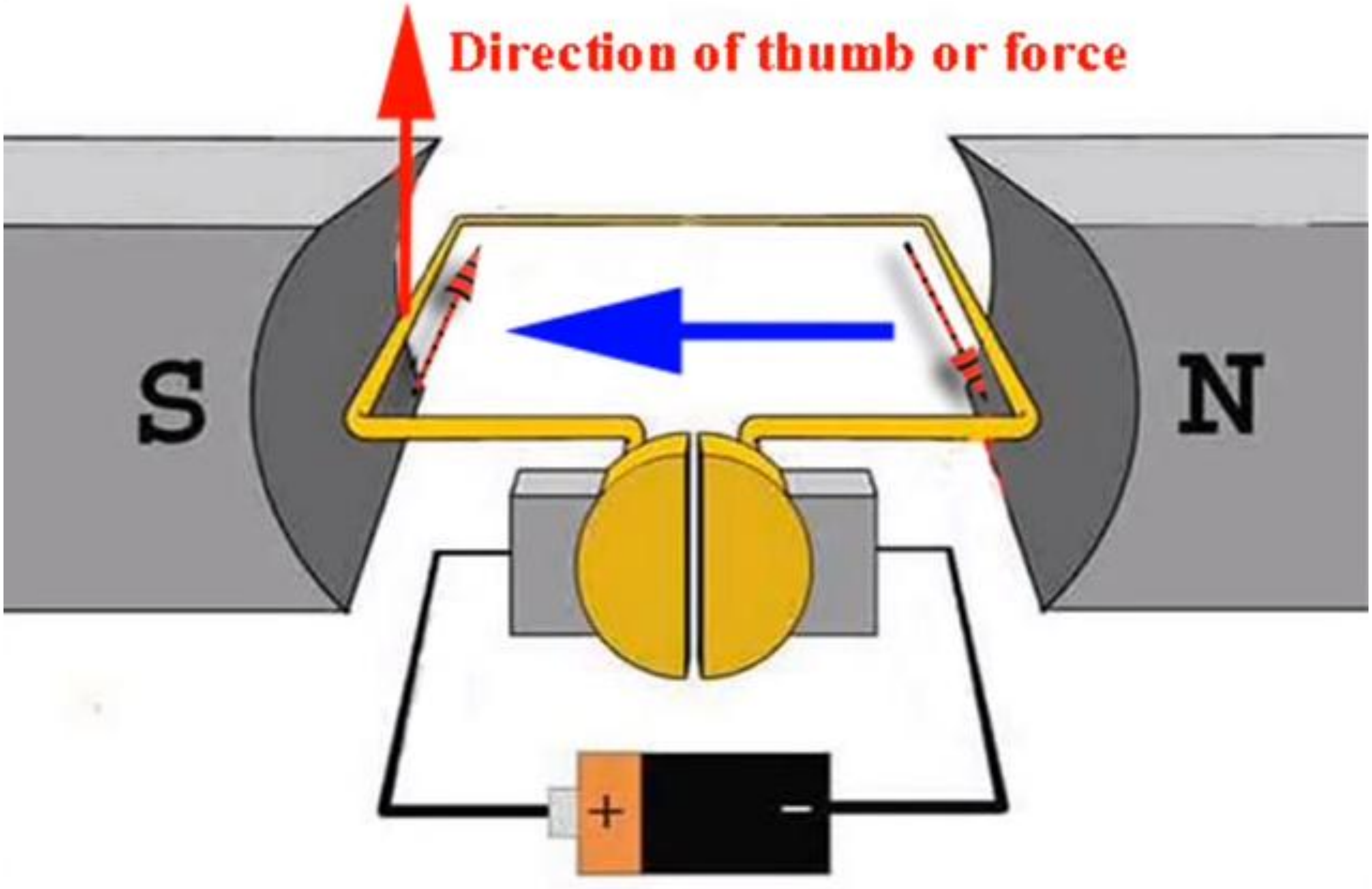


- Due to these upward & downward forces, turn continue to rotate in CW direction.

PRINCIPLE OF OPERATION OF A DC MOTOR

Conclusion:

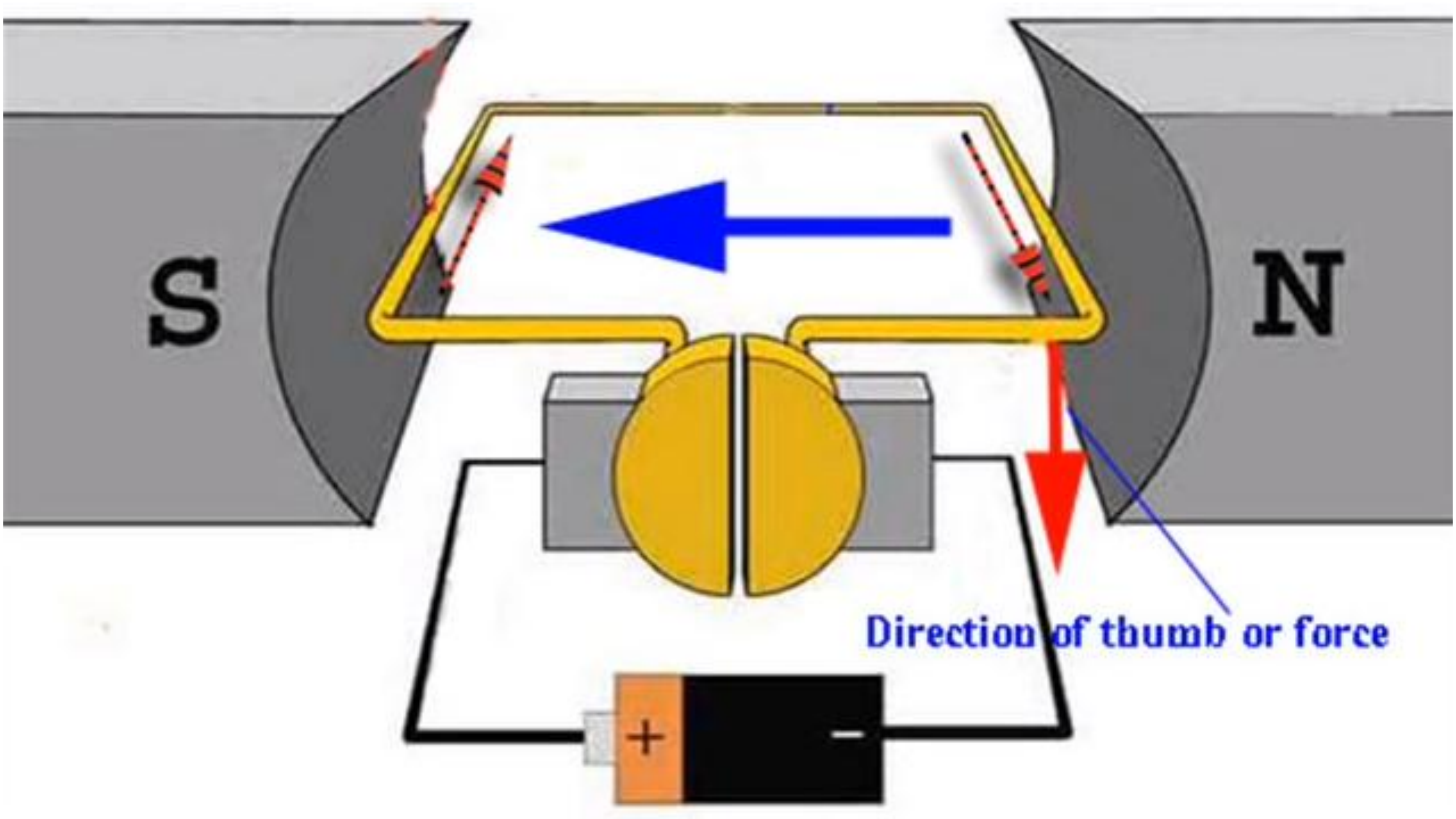
Whichever conductor comes to the south pole experiences a upward mechanical force



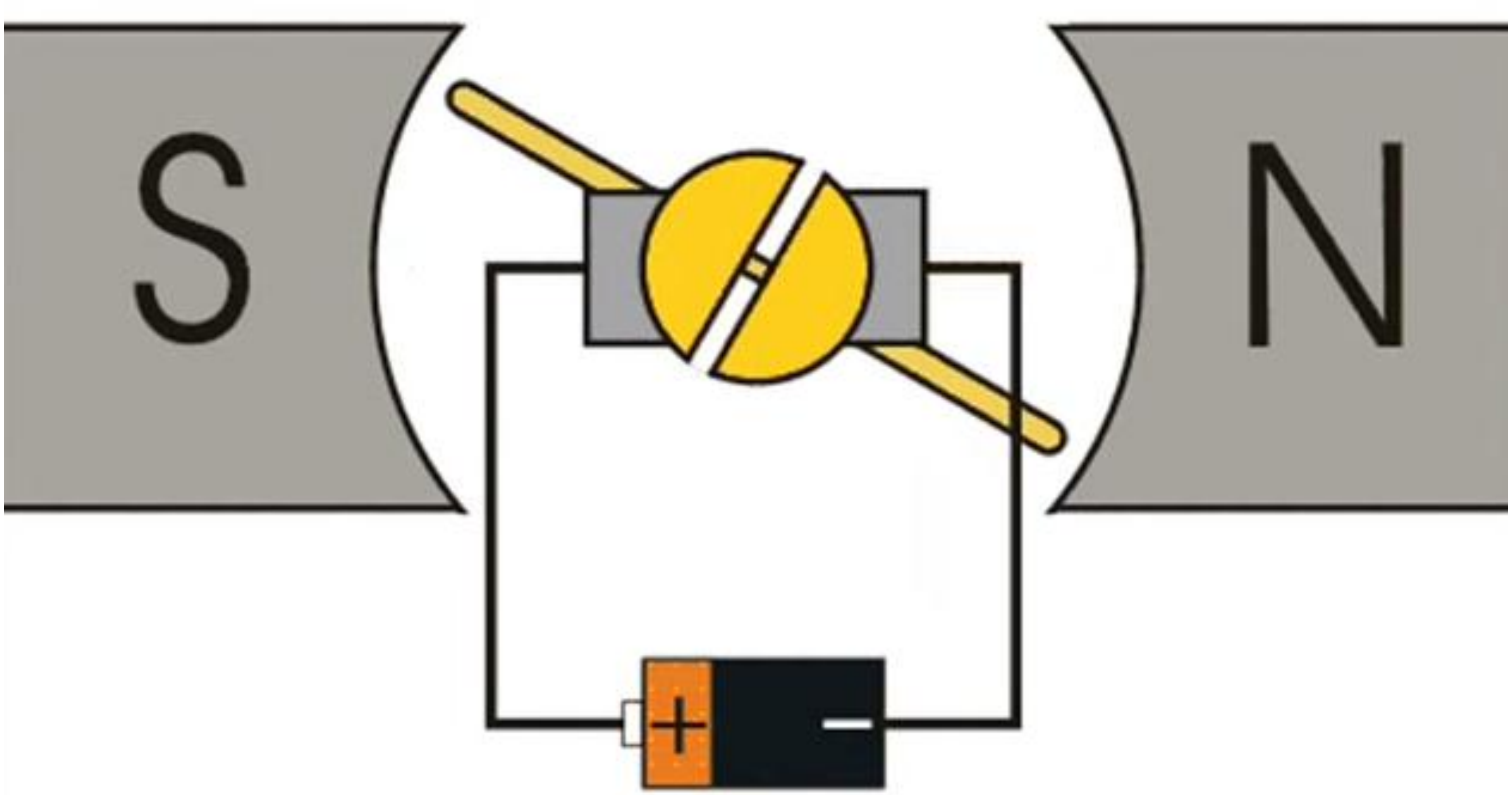
PRINCIPLE OF OPERATION OF A DC MOTOR

Conclusion:

Whichever conductor comes to the north pole experiences a downwards mechanical force



PRINCIPLE OF OPERATION OF A DC MOTOR



Conclusion:

- Thus we get continuous rotation of the conductor until the supply is disconnected

PRINCIPLE OF OPERATION OF A DC MOTOR

- In actual practice there are multiple turns instead of a single turn in armature coils.

- Instead of two poles there are many poles.

Comparisons of electrical, hydraulic and pneumatic systems

	Electrical	*Hydraulic*	*Pneumatic*
Energy source	Usually from outside supplier	Electric motor or diesel driven	Electric motor or diesel driven
Energy storage	Limited (batteries)	Limited (accumulator)	Good (reservoir)
Distribution system	Excellent, with minimal loss	Limited basically a local facility	Good. can be treated as a plant wide service
Energy cost	Lowest	Medium	Highest
Points to note	Danger from electric shock	Leakage dangerous and unsightly. Fire hazard	Noise

Comparisons of electrical, hydraulic and pneumatic systems

	Electrical	*Hydraulic*	*Pneumatic*
Rotary actuators	AC & DC motors. Good control on DC motors. AC motors cheap	Low speed. Good control. Can be stalled	Wide speed range. Accurate speed control difficult
Linear actuator	Short motion via solenoid. Otherwise via mechanical conversion	Cylinders. Very high force	Cylinders. Medium force
Controllable force	Possible with solenoid & DC motors Complicated by need for cooling	Controllable high force	Controllable medium force