Electric Motors
BEE401

-Presented By
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ATMECE

Module-1

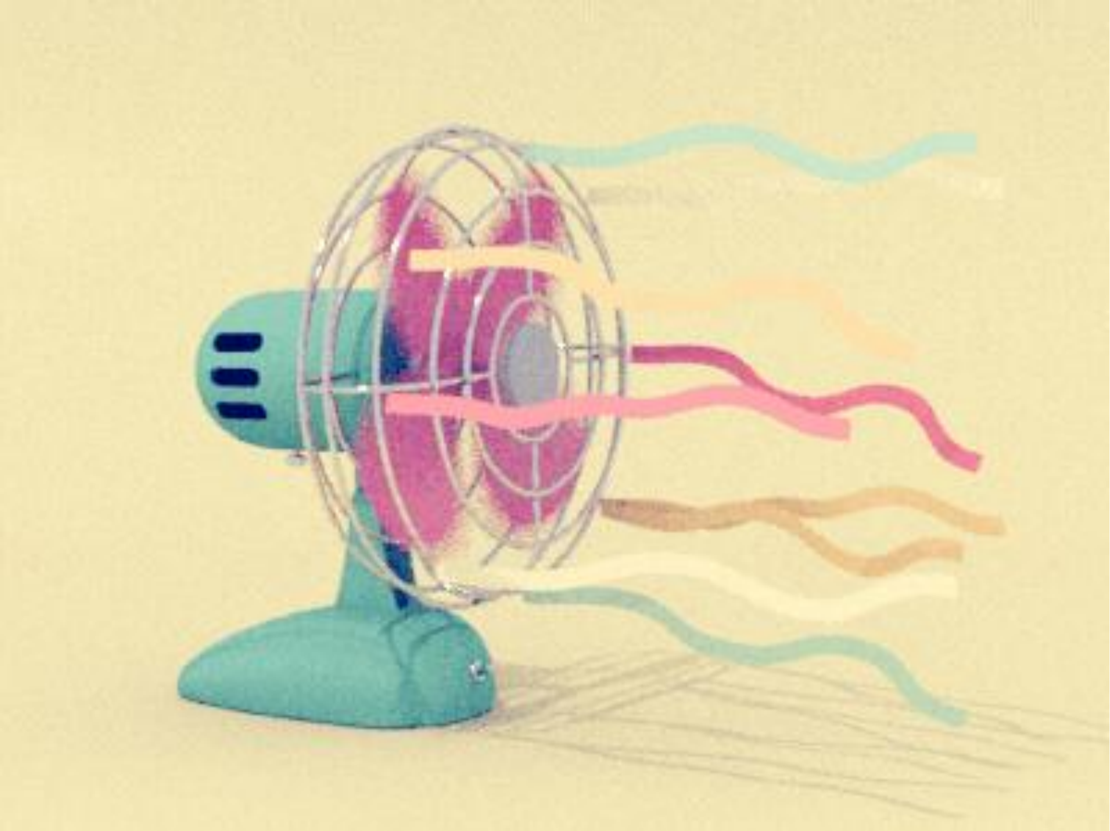
DC Motors: Construction and Classification, Back emf, Torque equation, and significance of back emf, Characteristics of shunt, series & compound motors. Speed control of shunt. Application of motors

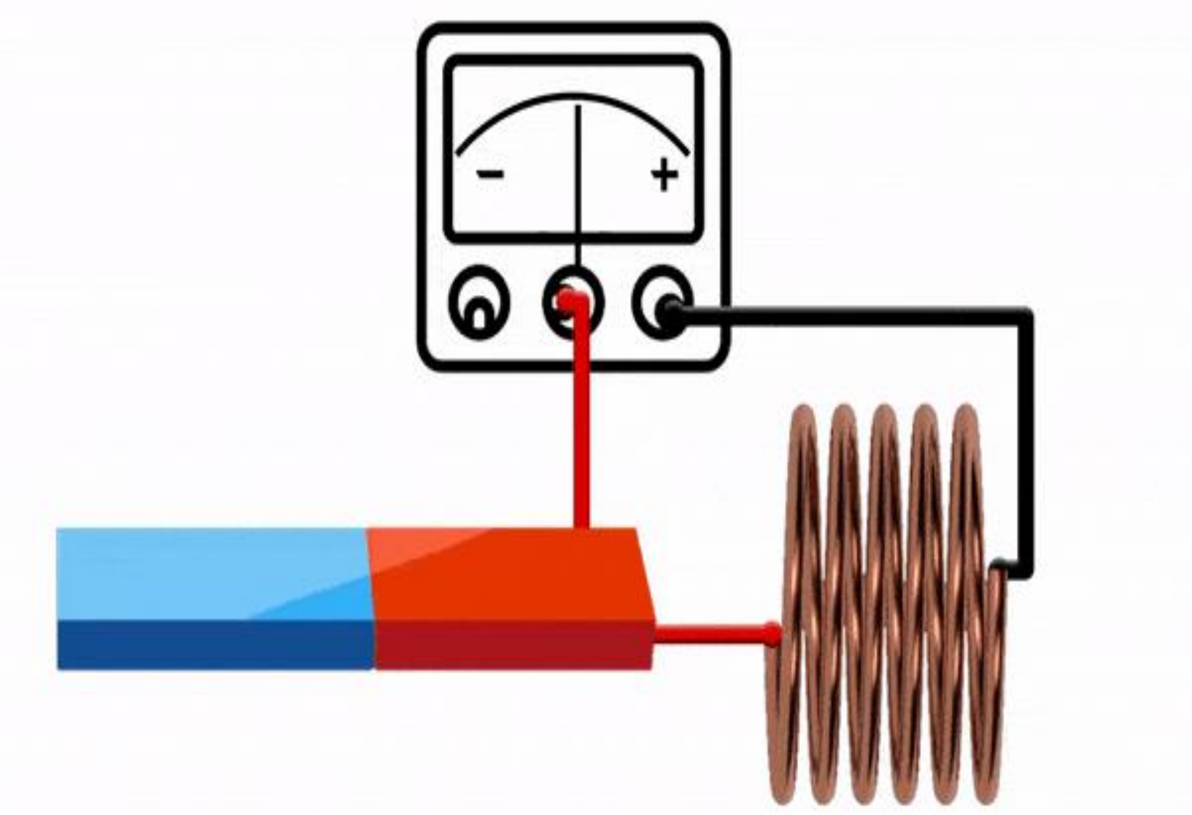
Losses and efficiency- Losses in DC motors, power flow diagram, efficiency, condition for maximum efficiency.

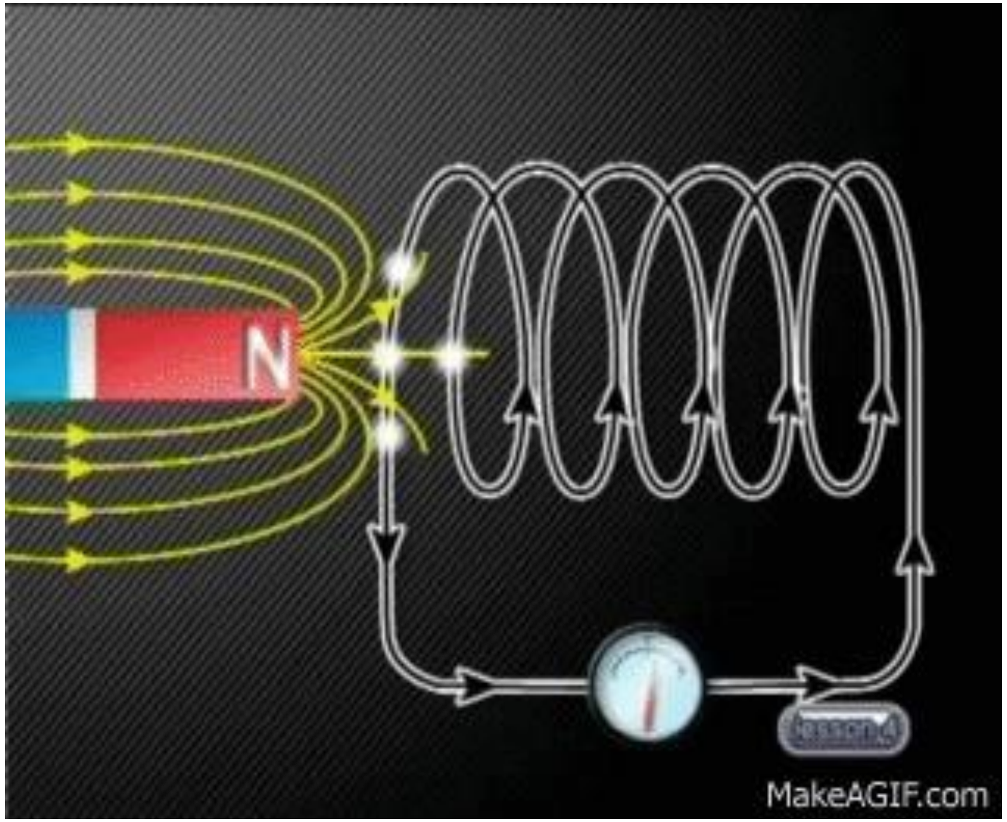
Testing of dc motors: Direct & indirect methods of testing of DC motors-Brake test, Swinburne's test, Retardation test, Hopkinson's test, Field's test, merits and demerits of tests. Numerical as applicable

The Machines are thus classified as,

1. Generator
2. motor

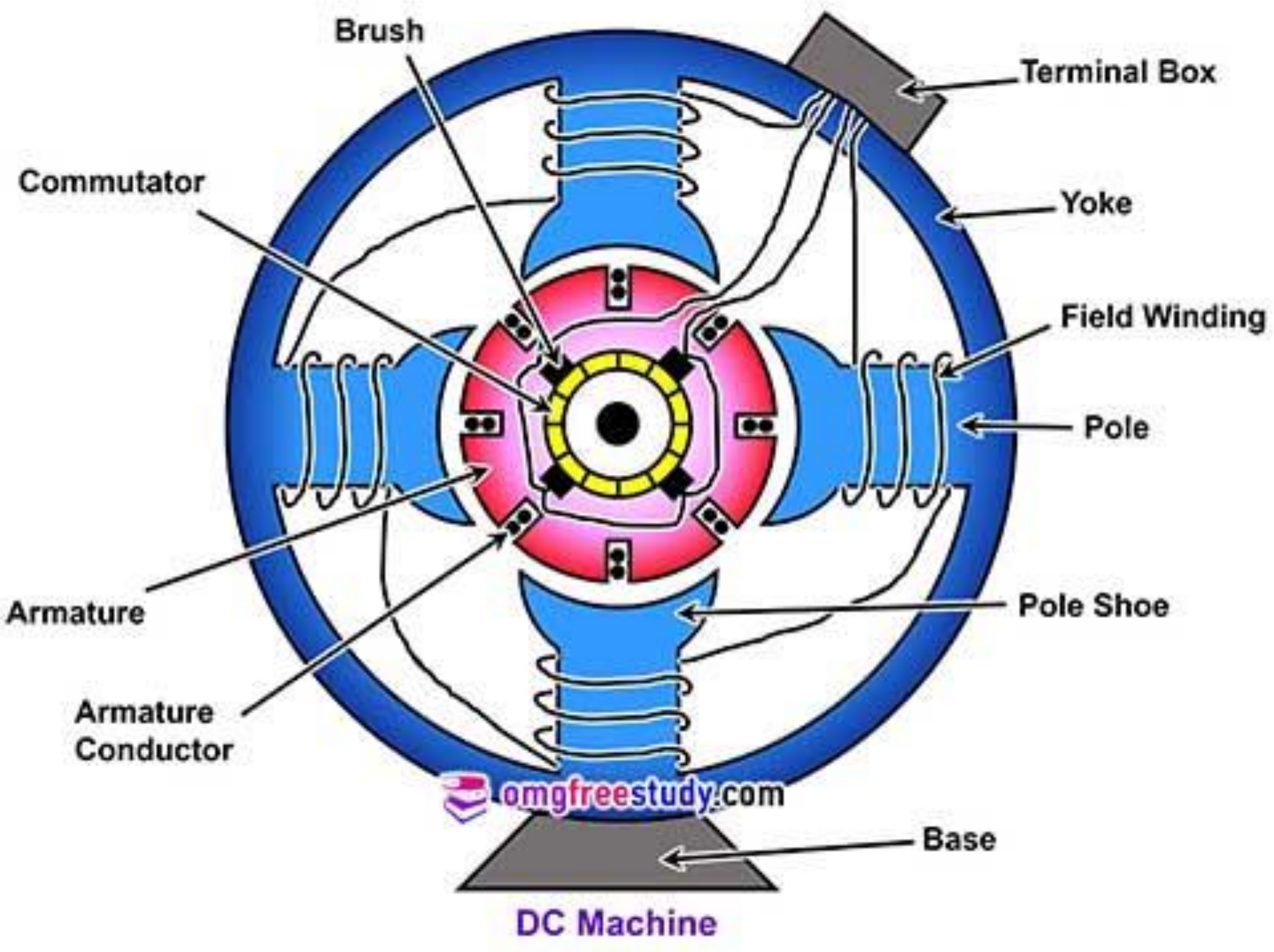




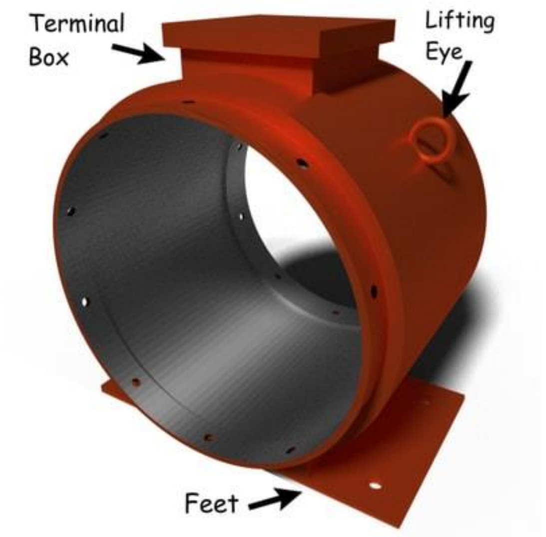


Faraday's laws of electromagnetic Induction

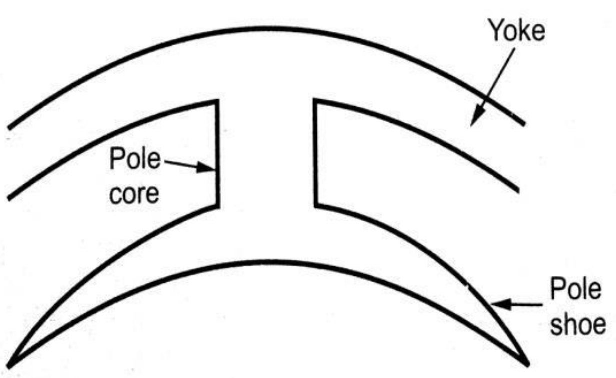
Lenz's Law

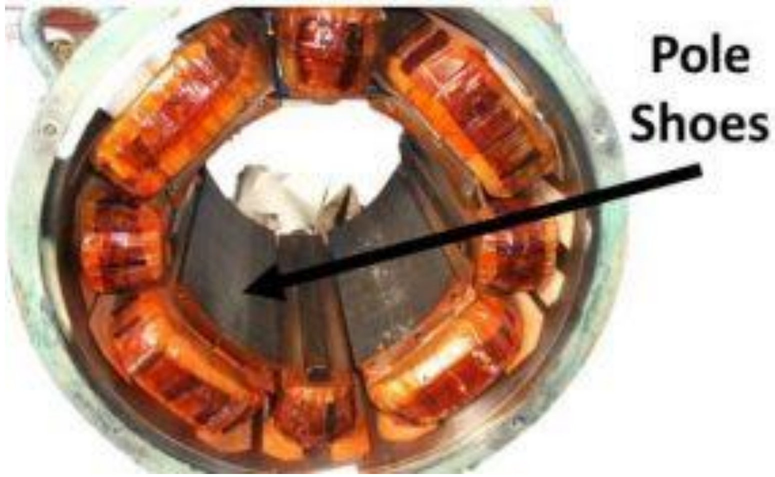

Brush
Terminal Box
Commutator
Yoke
Field Winding
Pole
Armature
Pole Shoe
Armature Conductor
omgfreestudy.com
Base
DC Machine

Yoke:.

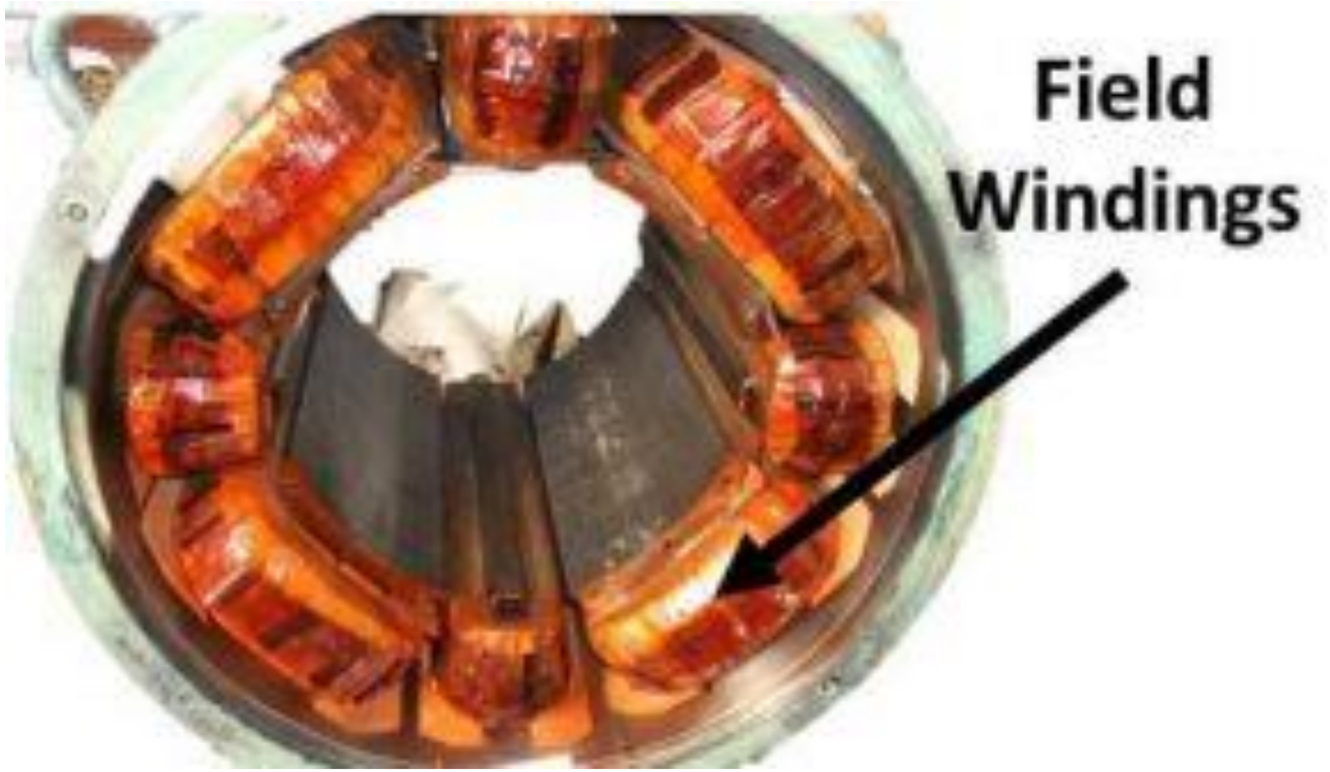


Poles and pole shoes:

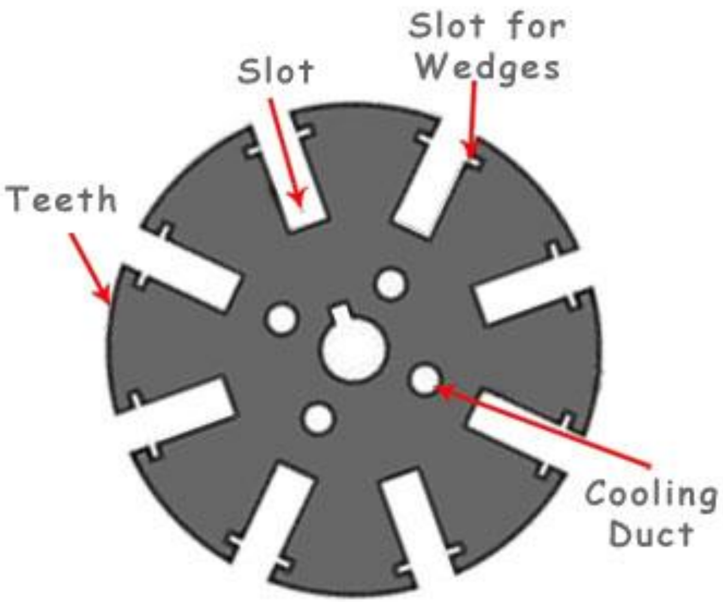




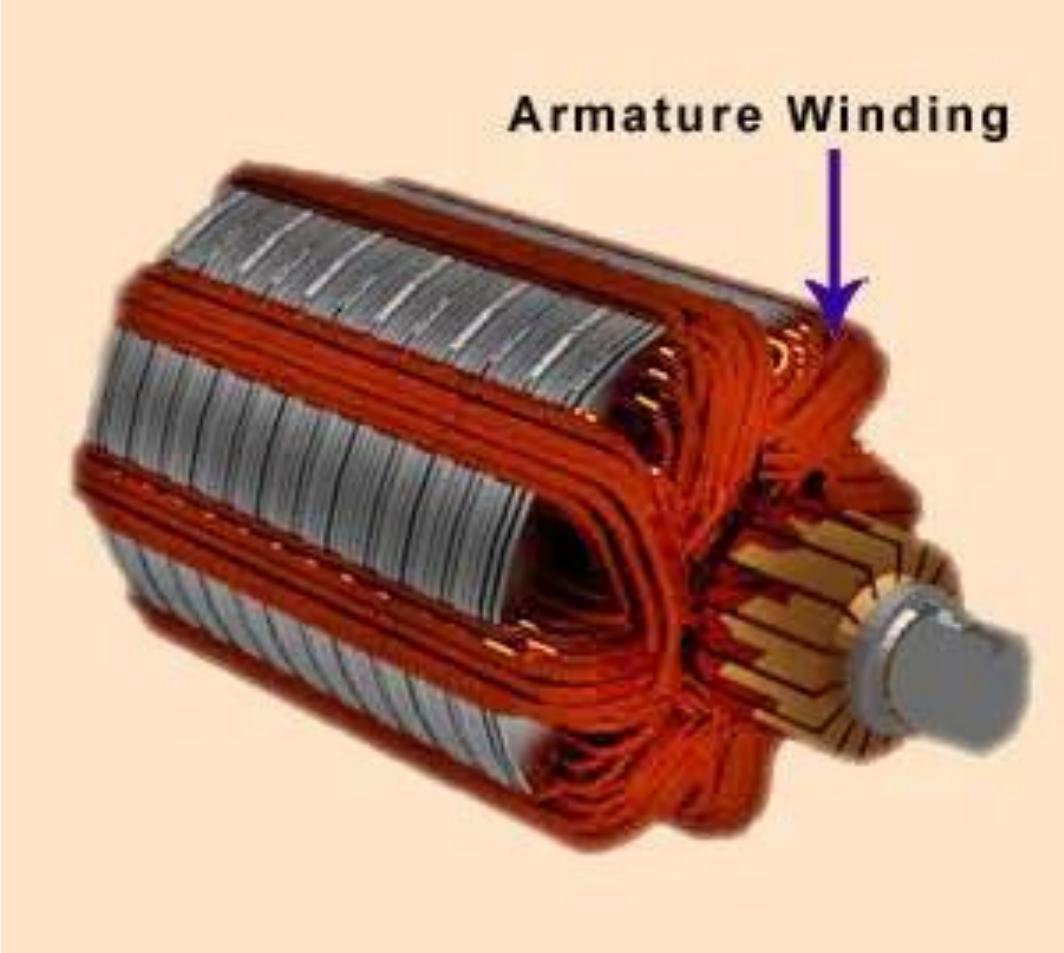
Field winding:



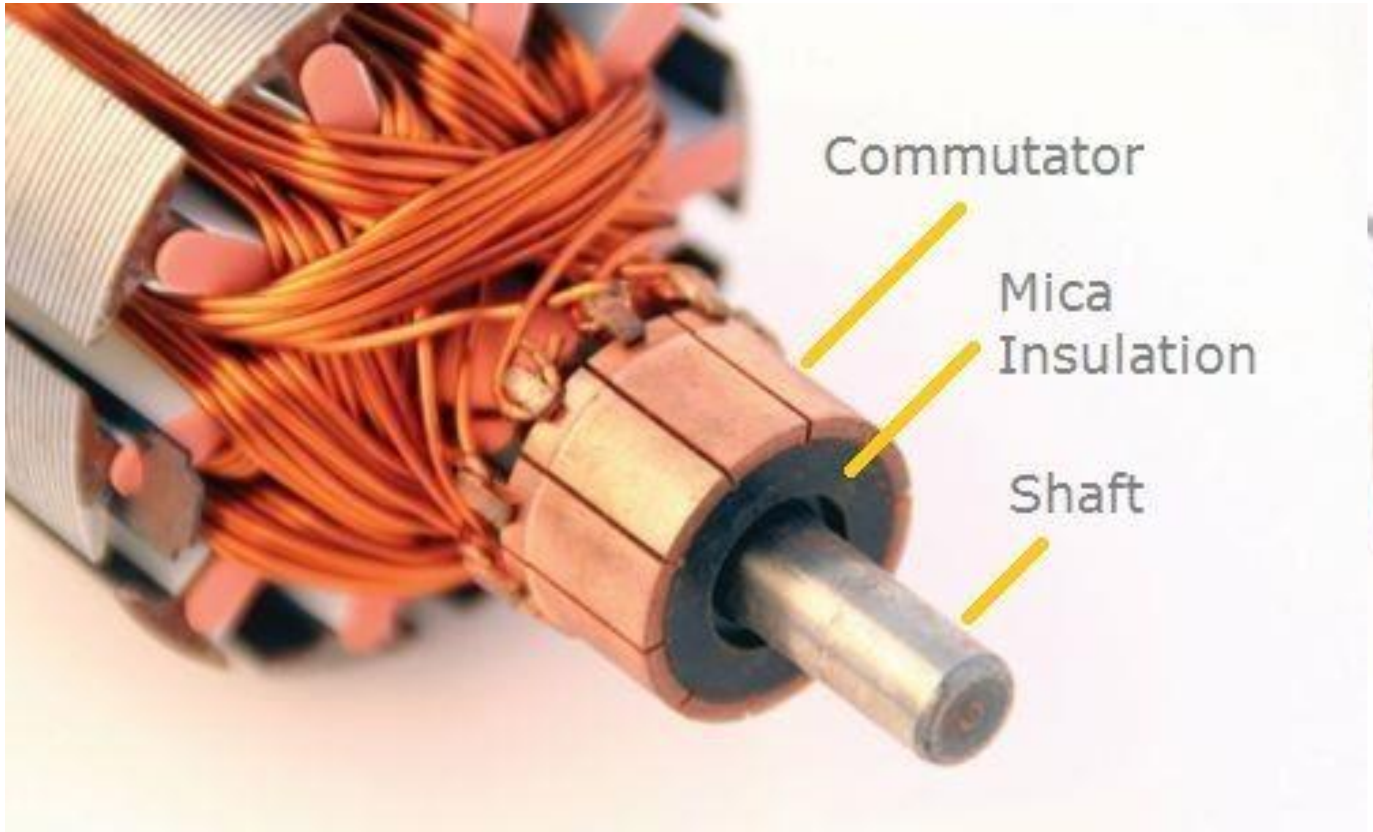
Armature core:

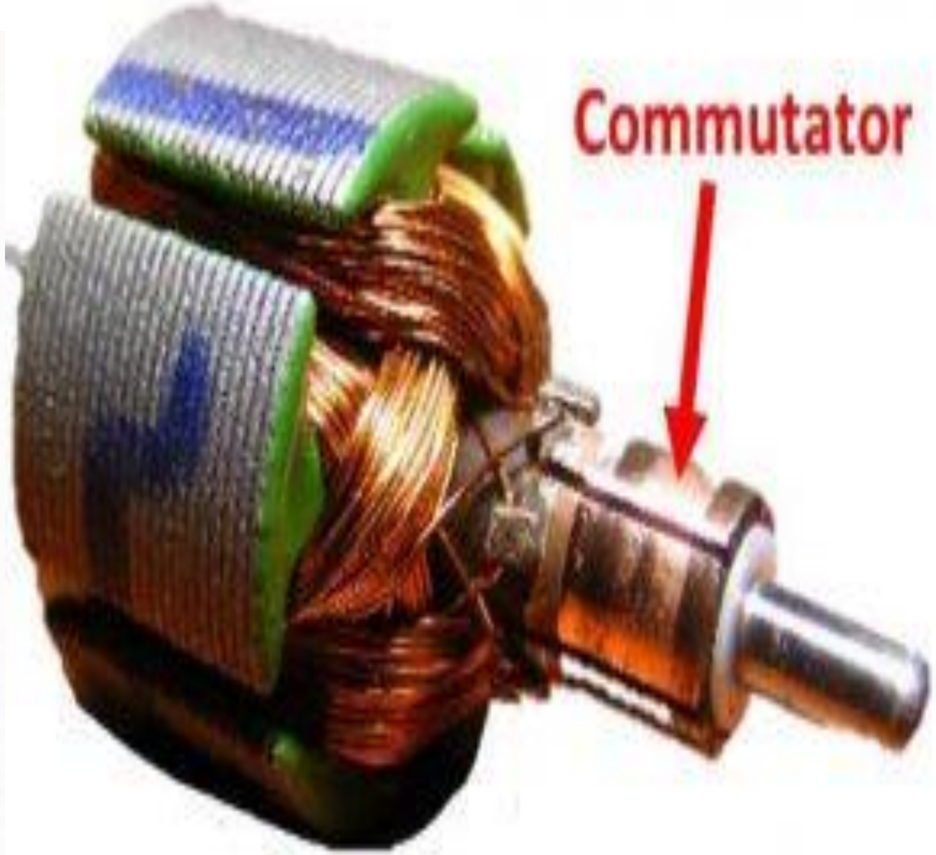


Armature winding:

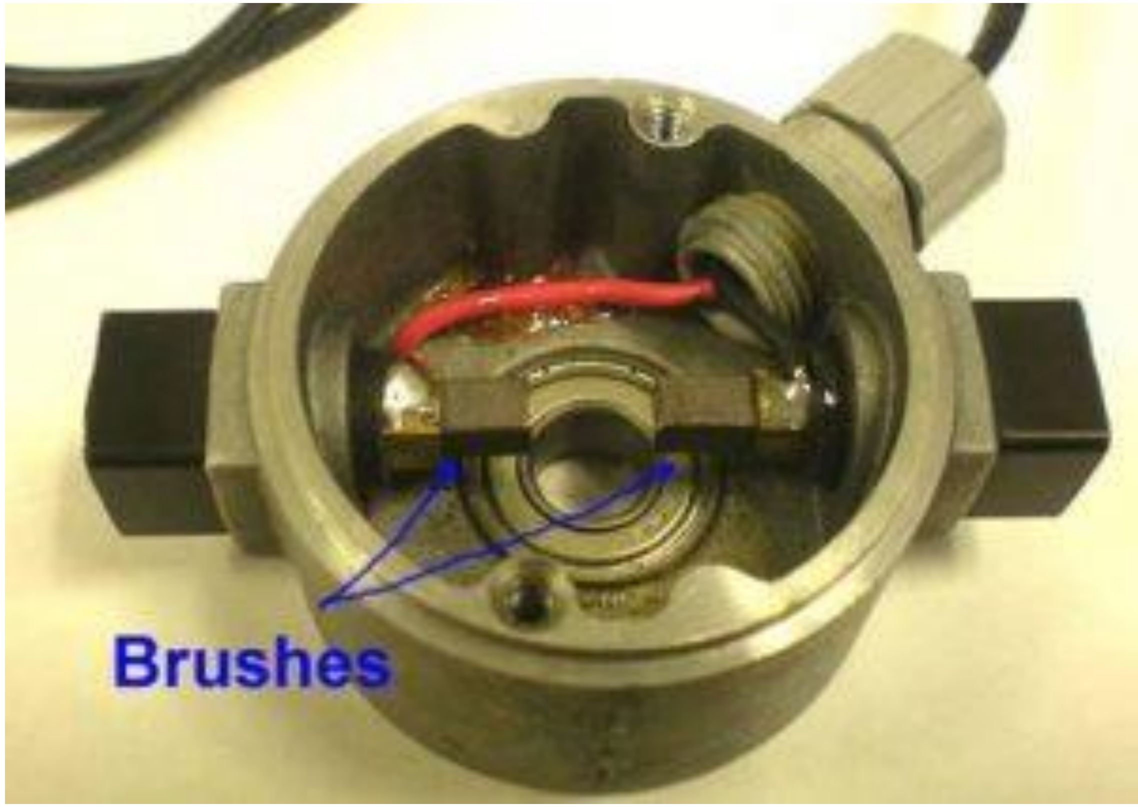


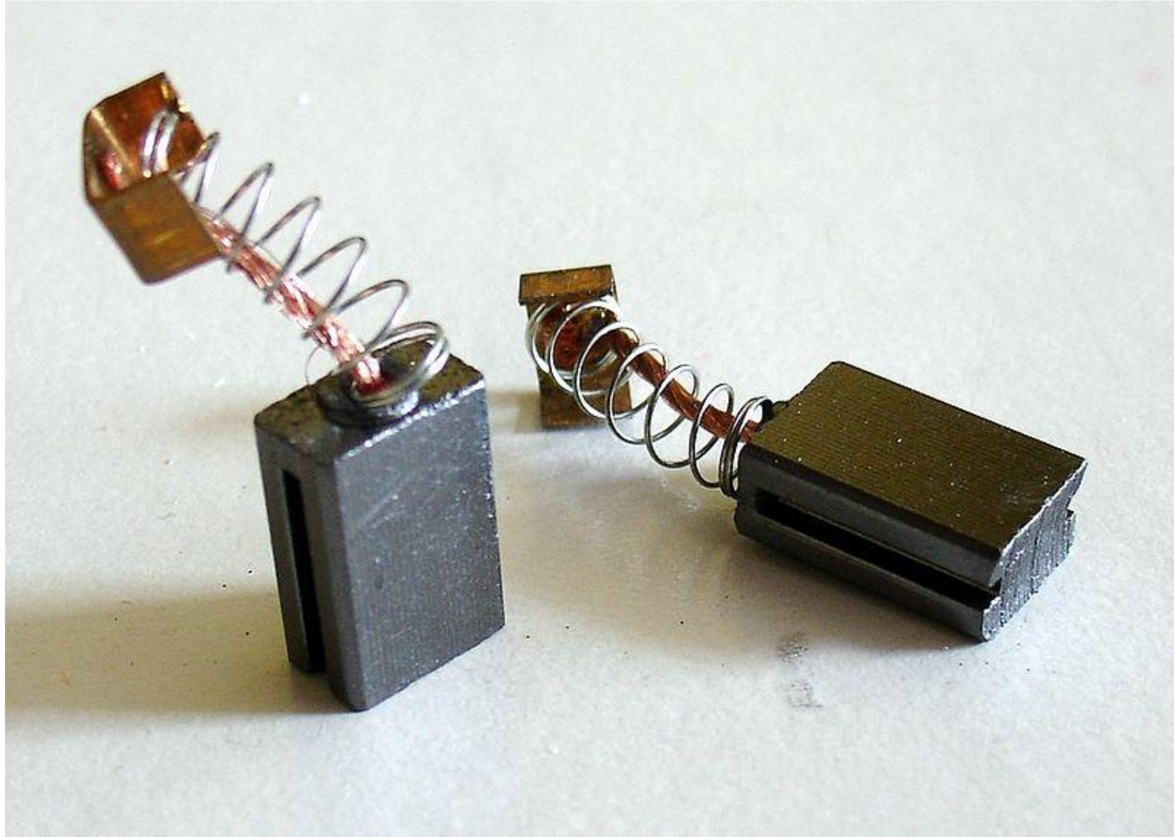
Commutator and brushes:





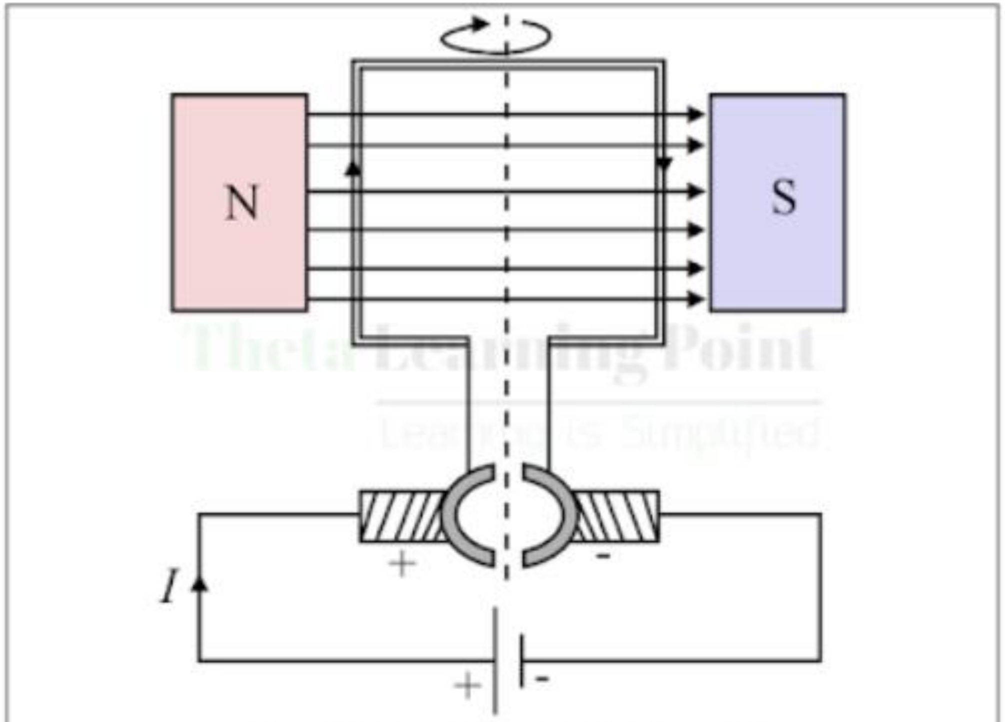
Brushes and Brush Gears:





Working Principle of DC Motor

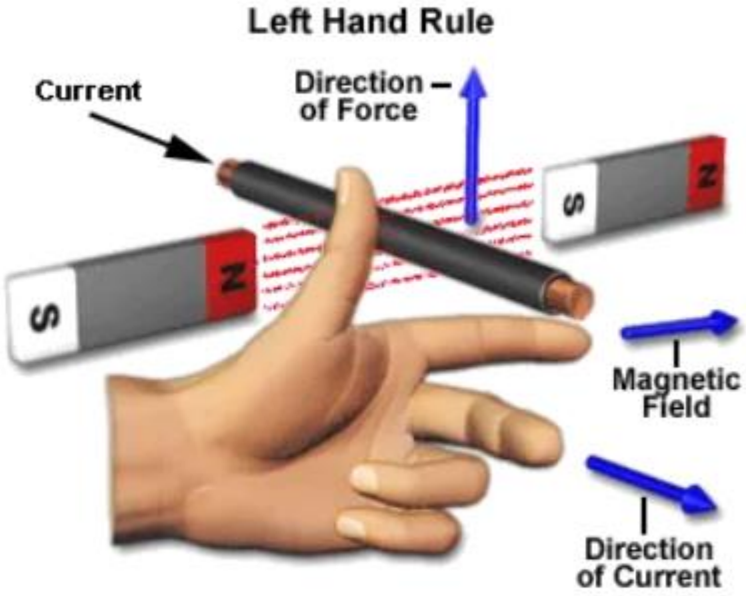
- The working of a DC motor is based on the simple fact that when a current-carrying conductor is placed in a magnetic field it experiences a force.
- The field winding (on the stator) and the armature winding (on the rotor) are simultaneously excited by the DC supply. The magnetic field is produced by the field winding.



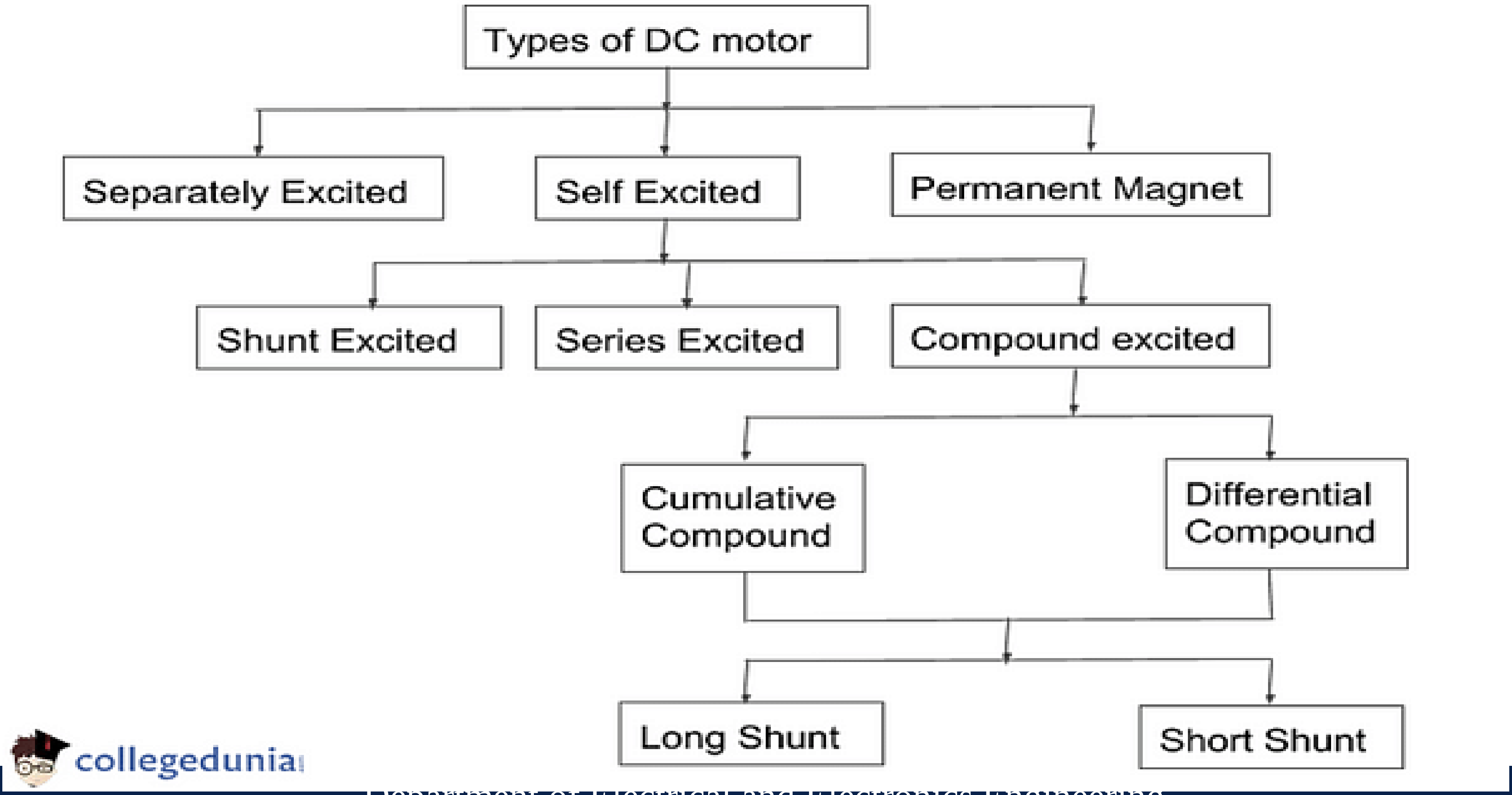
Working Principle of DC Motor

The dc current from the dc supply flows through the carbon brushes, commutator segments and the armature conductors. The current in these conductors produces their own magnetic field which interacts with the main field.

The conductors experience mechanical force in a direction determined by Fleming's left hand rule.

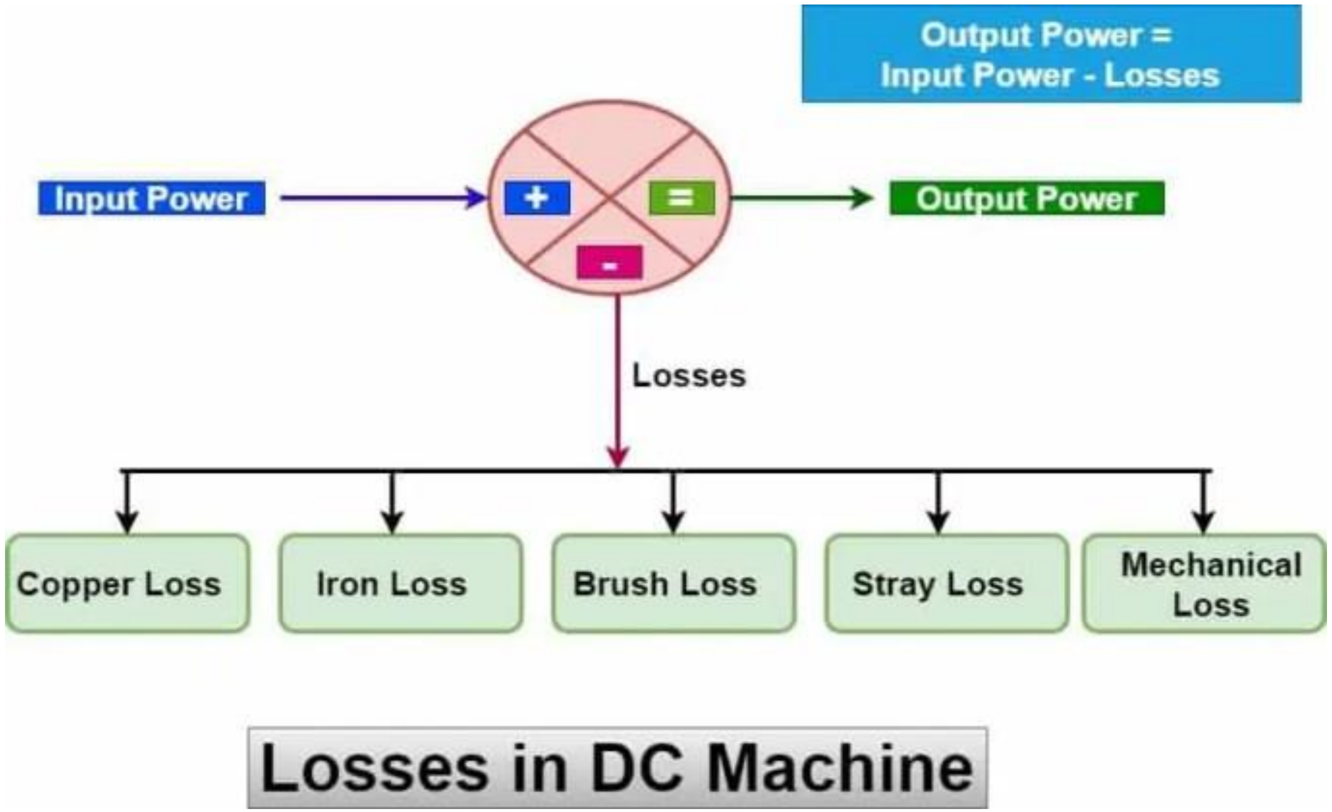


Classification of DC Motor:



Four-Point Starter:

Losses in DC Machine:



1. Copper Losses: Copper losses are due to the current flowing in a winding.

Copper Loss in Armature Winding: The armature of the DC machine has very low resistance. The resistance of the armature is denoted by Ra.

Armature copper loss = Ia^2Ra

The copper loss in the armature is about 25 to 30 % of the full load loss.

Copper Loss in Field Winding: The copper loss in the field winding is expressed as;

Field winding copper loss = $I_{sh}{}^2R_{sh}$

The field winding copper loss is about 20-25 % of the full load loss of the DC machine.

2. Magnetic Losses (Iron or Core Losses) :

Hysteresis Loss in DC Machine: Due to a constant magnetic reversal in the armature, some energy is consumed during a magnetic reversal is called hysteresis loss. The hysteresis loss depends on the quality and volume of the core material.

$$W_h = n\, B_m^{\,1.6}\, f\, V \text{ watts}$$

W_h = hysteresis loss (Watt)

η = Steinmetz hysteresis coefficient, depending on the material (J/m^3)

B_m = Maximum flux density (W_b/m^2)

n =Steinmetz exponent, ranges from 1.5 to 2.5, depending on the material

f = frequency of magnetic reversals per second (Hz)

V = volume of magnetic material (m^3)

Eddy Current Loss in DC Machine:

$$We=KB_m^2f^2t^2V$$

Where,

We=Eddy current loss(watt)

B= Maximum flux density W_b/m^2

f= frequency in Hz

t= thickness of lamination (m)

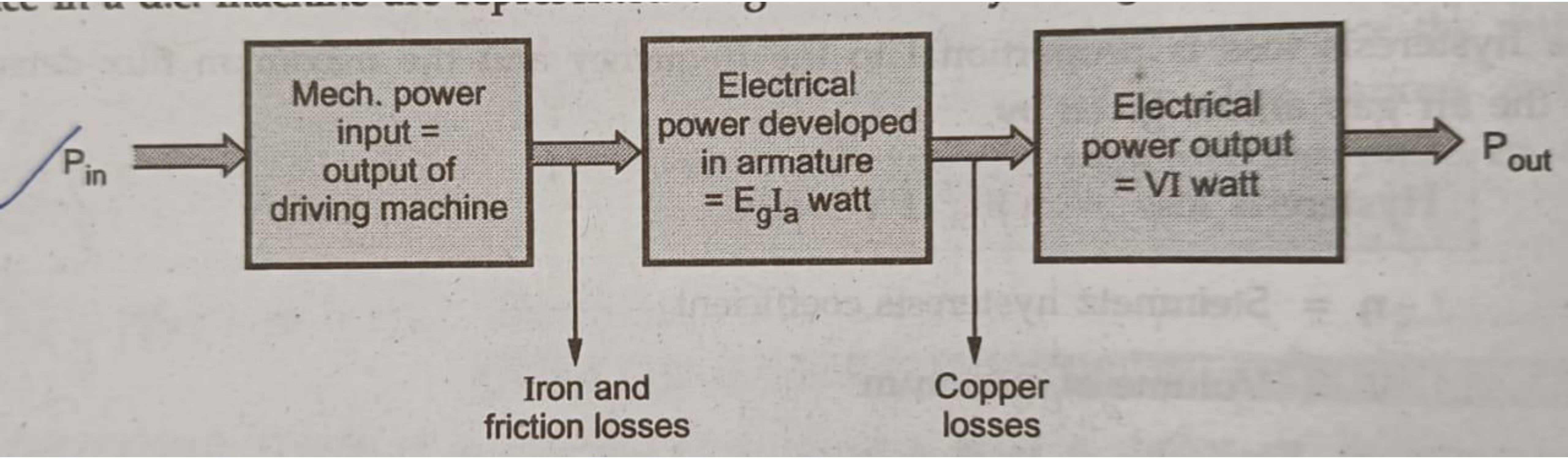
V= Volume of the material (m^3)

K= Eddy Current Constant

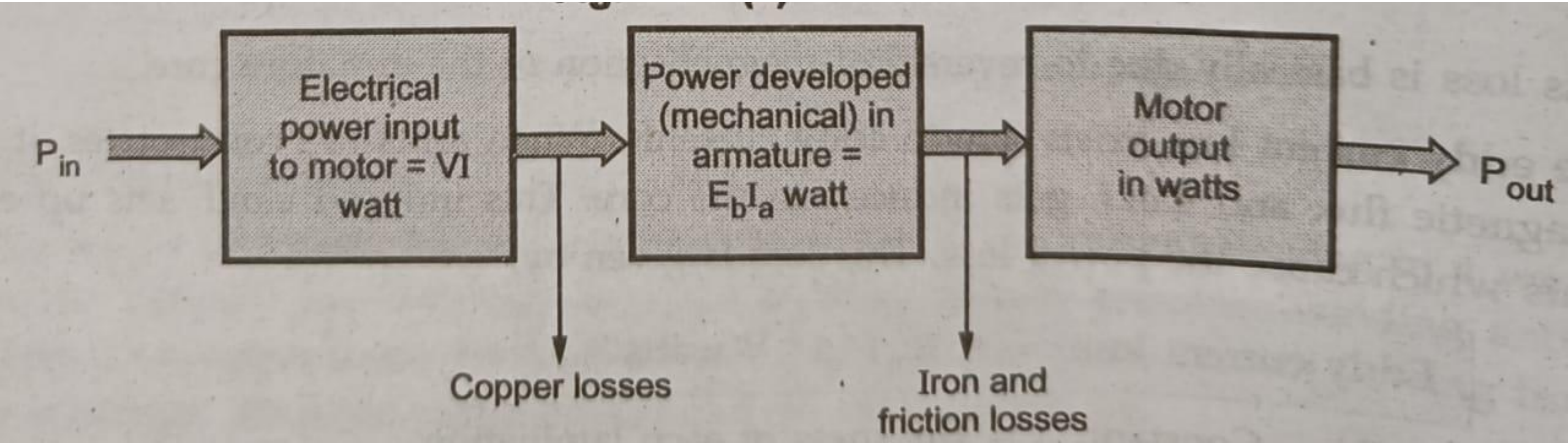
Mechanical Loss in DC Machine: In a DC machine, the field is a stationary part and the armature is a rotating part. The armature rotates on the bearings. The energy loss in the form of heat occurs due to friction between the inner cage and outer cage of the bearing.

Stray Losses in DC Machine: Stray losses are miscellaneous losses that are difficult to determine. The various reasons for the stray losses in DC machines are short circuit current undergoing commutation, distortion of flux, etc. The stray losses in the DC machine are about 1 % of the total losses.

Power Flow Diagram of Generator:



Power Flow Diagram of Motor:



The efficiency of DC Machines:

Electrical Efficiency,

$$n_e = \frac{Total\ power\ supplied\ to\ the\ load}{Total\ \ power\ generated}$$

$$n_e = \frac{VI}{E_g I_a} * 100$$

Mechanical Efficiency,

$$n_m = \frac{Total\ power\ generated\ in\ armature}{Mechanical\ power\ input\ to\ the\ generator}$$

$$n_m = \frac{E_g I_a}{Output\ of\ driving\ machine} * 100$$

Commercial or Overall efficiency:

$$n_c = \frac{Total\ power\ supplied\ to\ the\ load}{Total\ mechanical\ power\ input\ to\ the\ generator}$$

$$n_c = \frac{P_{out}}{P_{in}} * 100 = \frac{VI}{P_{in}} * 100$$

The overall efficiency of DC generator can be expressed as

$$n_g = \frac{Output}{Input} * 100$$

$$n_g = \frac{VI_L}{VI_L + Total\ losses} * 100$$

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The overall efficiency of DC motor can be also expressed as

$$n_M = \frac{Output}{Output - Total\ losses} * 100$$

$$n_M = \frac{Output}{Input} * 100$$

$$n_M = \frac{Input - Total\ losses}{Input} * 100$$

$$n_M = \frac{VI_L - Total\ losses}{VI_L} * 100$$

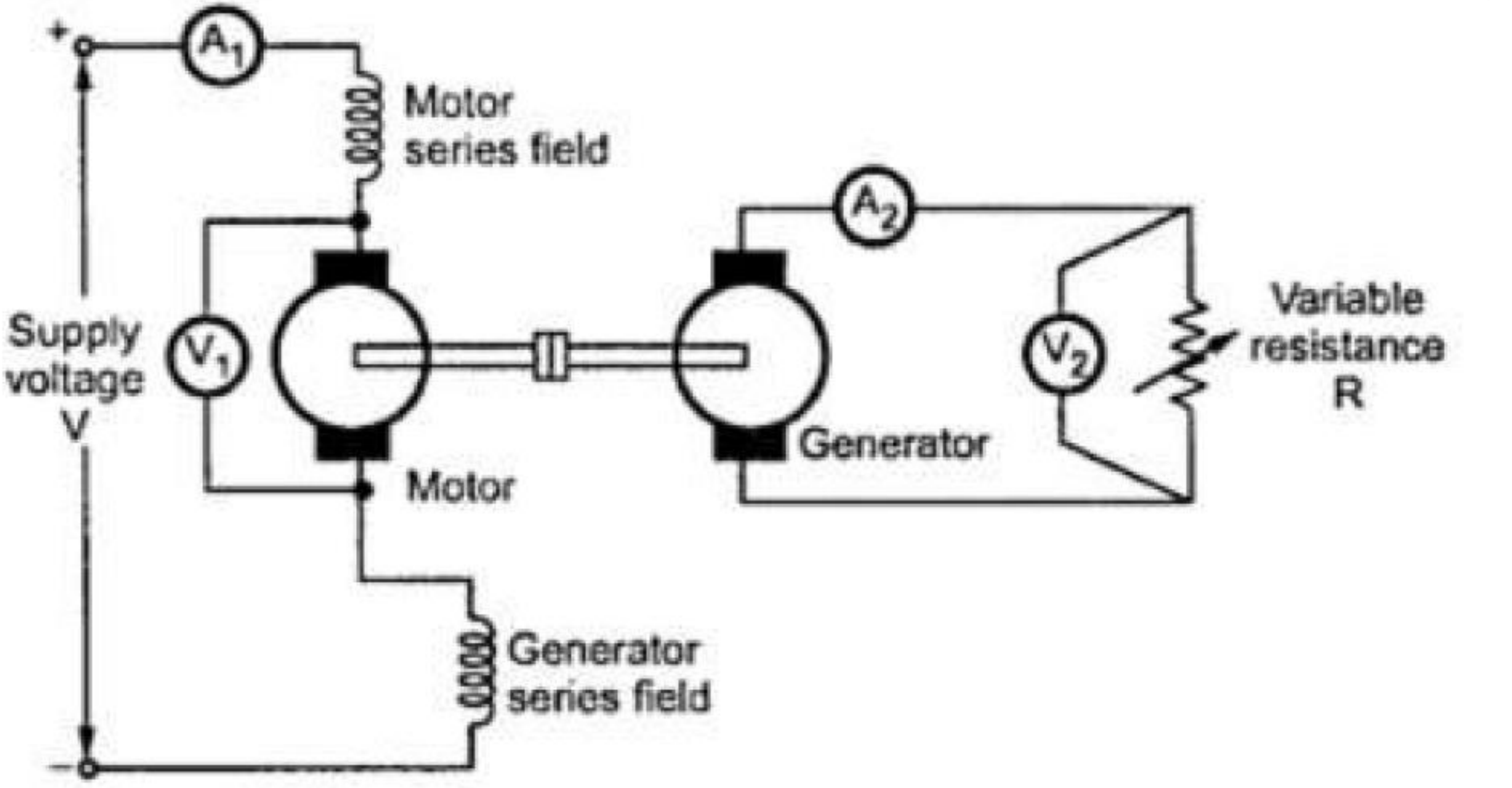

Fig. 1 Field test Experimental Set Up


Thank you