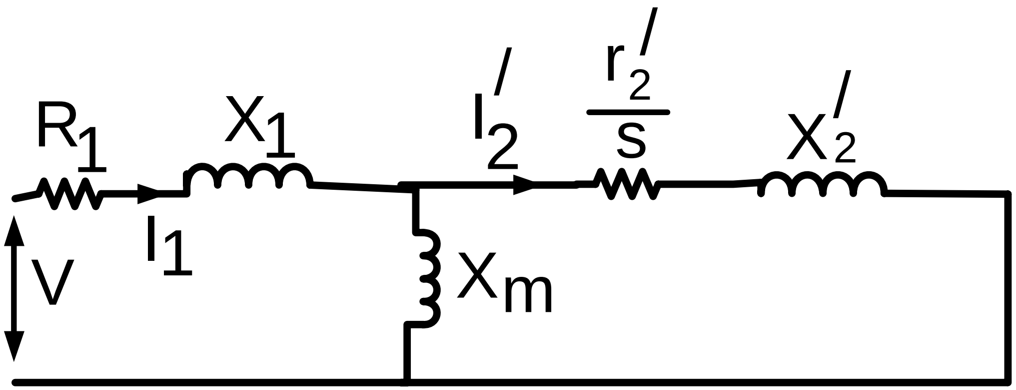
EE 111

Introduction to Electrical Systems

Lecture - 34

Performance features

I/M never runs at synch. speed = Asynchronous Motor



Starting Current

Starting Torque

Power Factor

Efficiency

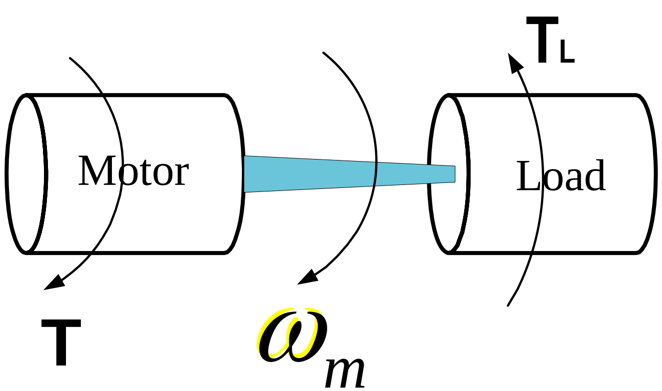
Name Plate Rating:

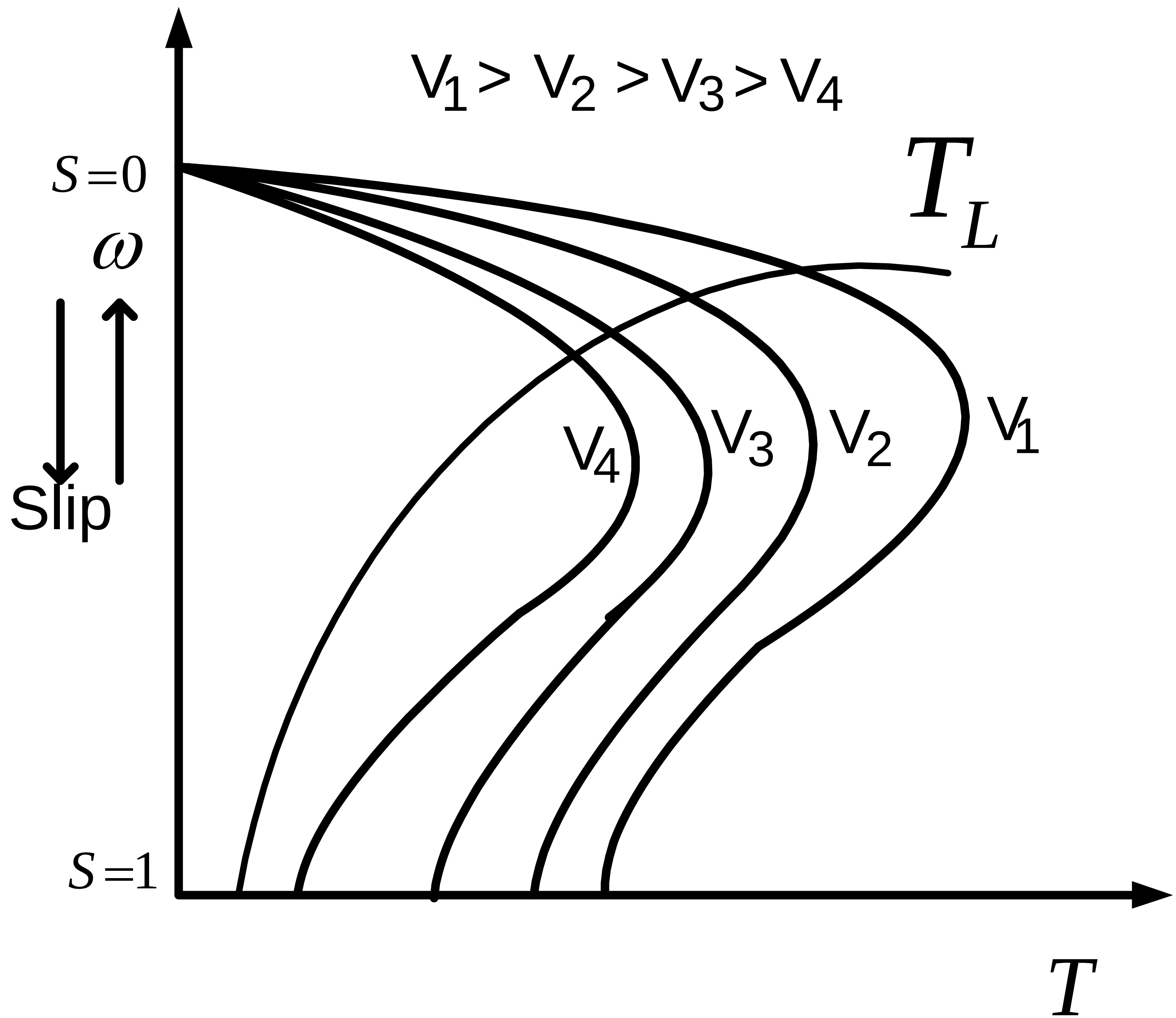
12 kW, 3-ϕ, 50 Hz, 25 A, 400 V, 1440 rpm delta connected, 0.8 pf (lag) squirrel cage induction motor

Generating Mode of operation

Variable terminal voltage control

$$T = \frac{3}{\omega_s}\left[\frac{V_t^2 \dfrac{r_2'}{s}}{(R_t + \dfrac{r_2'}{s})^2 + (X_t + X_2')^2}\right] \simeq \frac{3}{\omega_s}\frac{V_t^2}{r_2'} s$$




V1 > V2 > V3 > V4
T_L
S = 0
ω
Slip
S = 1
V4
V3
V2
V1
T

Variable terminal voltage control

- Poor efficiency

Neglecting stator losses and rotational losses:

$$P_m = (1 - s)P_g$$

$$\eta = \frac{P_m}{P_g} = (1 - s)$$

Rotor resistance Control: Wound rotor Motors

$$T = \frac{3}{\omega_s}\left[\frac{V_t^2 \frac{r_2'}{s}}{(R_t + \frac{r_2'}{s})^2 + (X_t + X_2')^2}\right] \simeq \frac{3}{\omega_s}\frac{V_t^2}{r_2'}s$$

Variable frequency Control

$$N_s = \frac{120f}{P}$$

$$E_{rated} = 4.44 k_{sw} N_{st} f_{rated} \phi_p$$

$$\phi_p = \frac{E_{rated}}{4.44 k_{sw} N_{st} f_{rated}}$$

In order to maintain air gap flux at its rated value:

Assuming, $V \simeq E$

$$f = k f_{rated}$$

$$E \simeq V = k V_{rated}$$

Therefore,

$$\frac{V}{f} = \frac{V_{rated}}{f_{rated}}$$

V / f Controlled induction motor drive

DC Machine

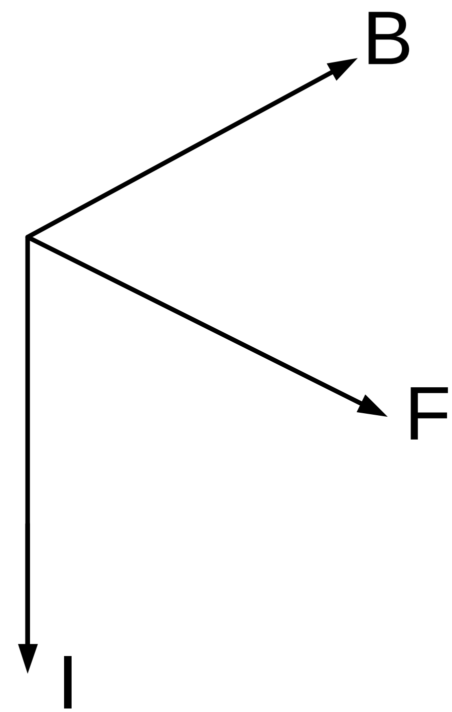
DC Machine:

DC Motor

DC Generator

Conductor carrying current when placed in a magnetic field experience Mechanical force.

Fleming's Left hand Rule

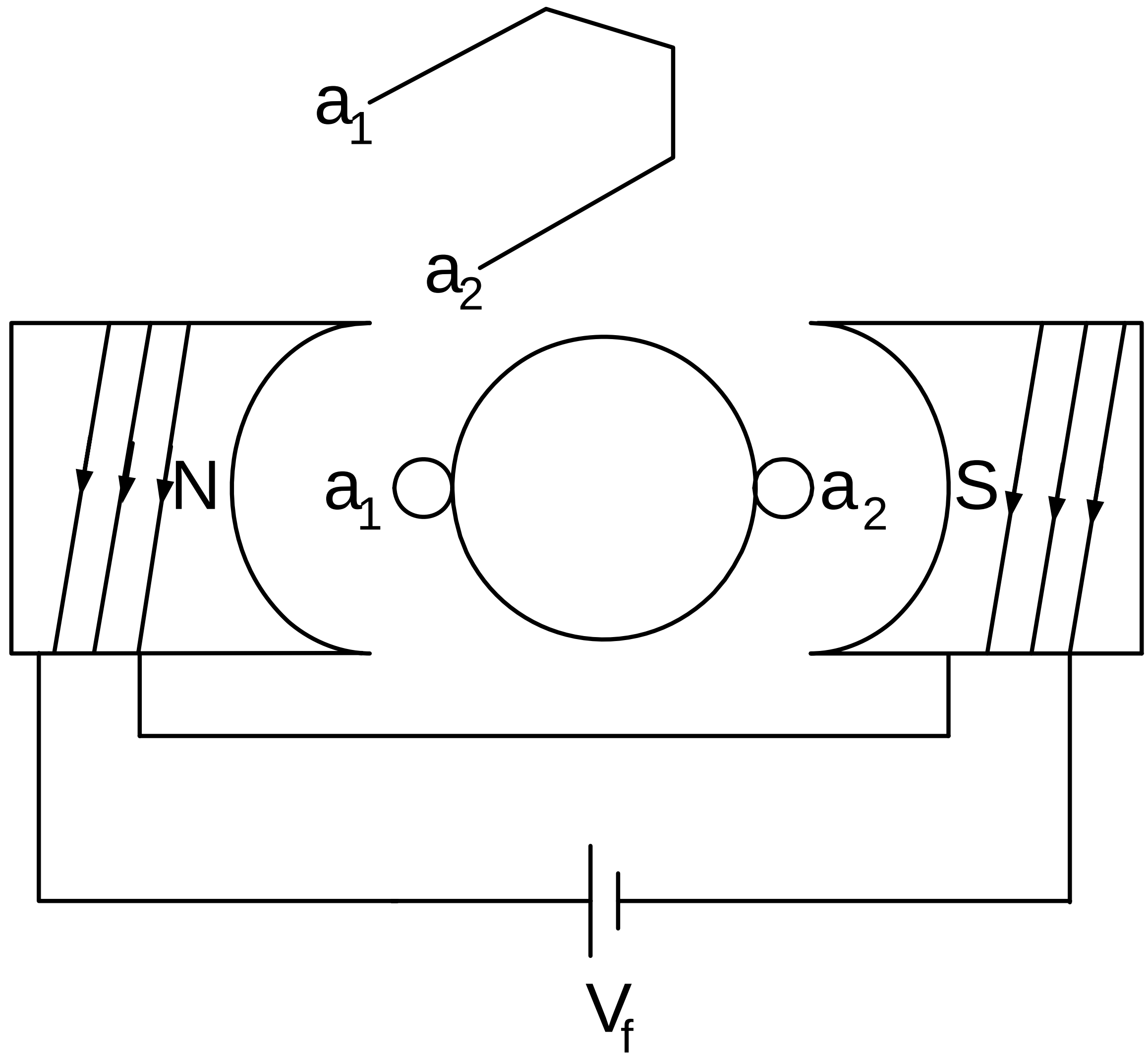


DC M/C : Principle of Operation

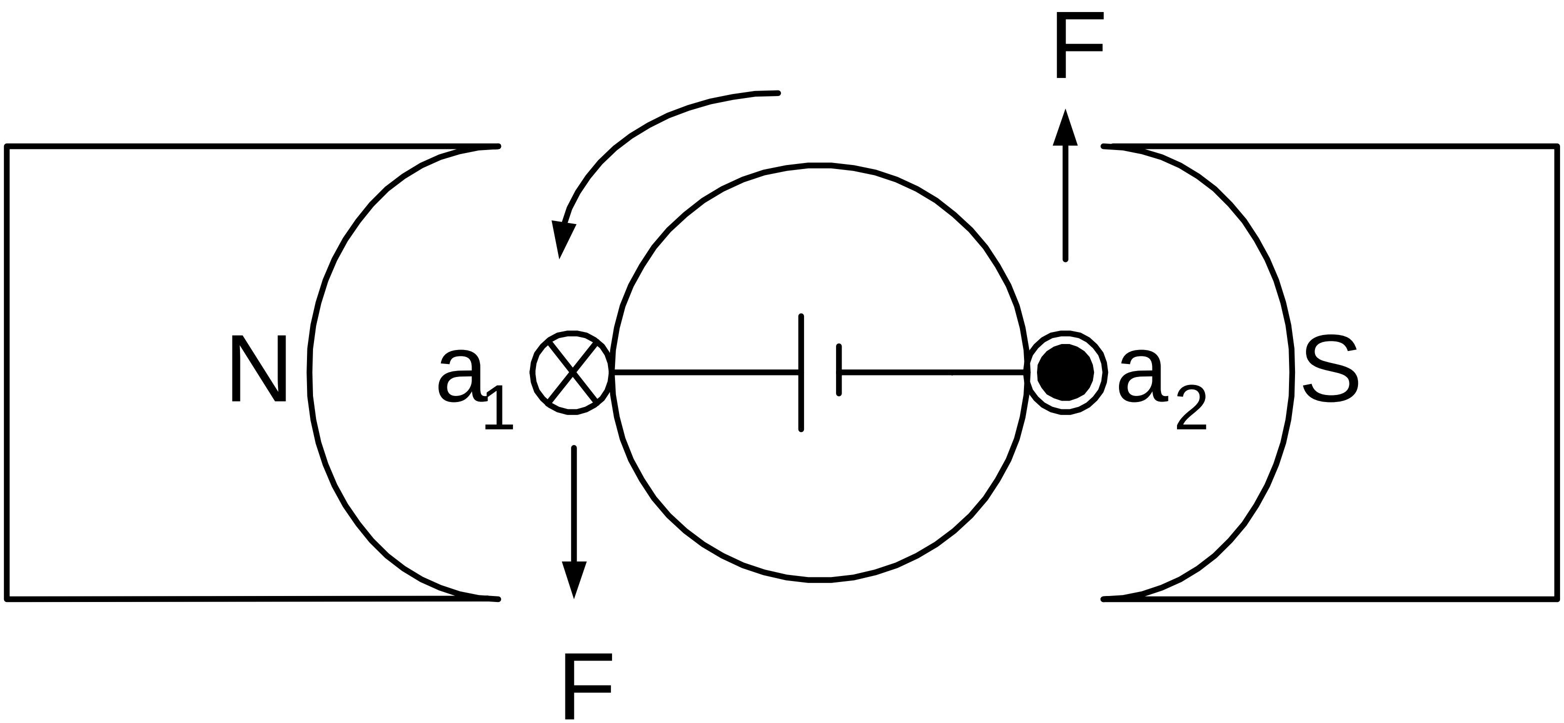
Field winding

Armature

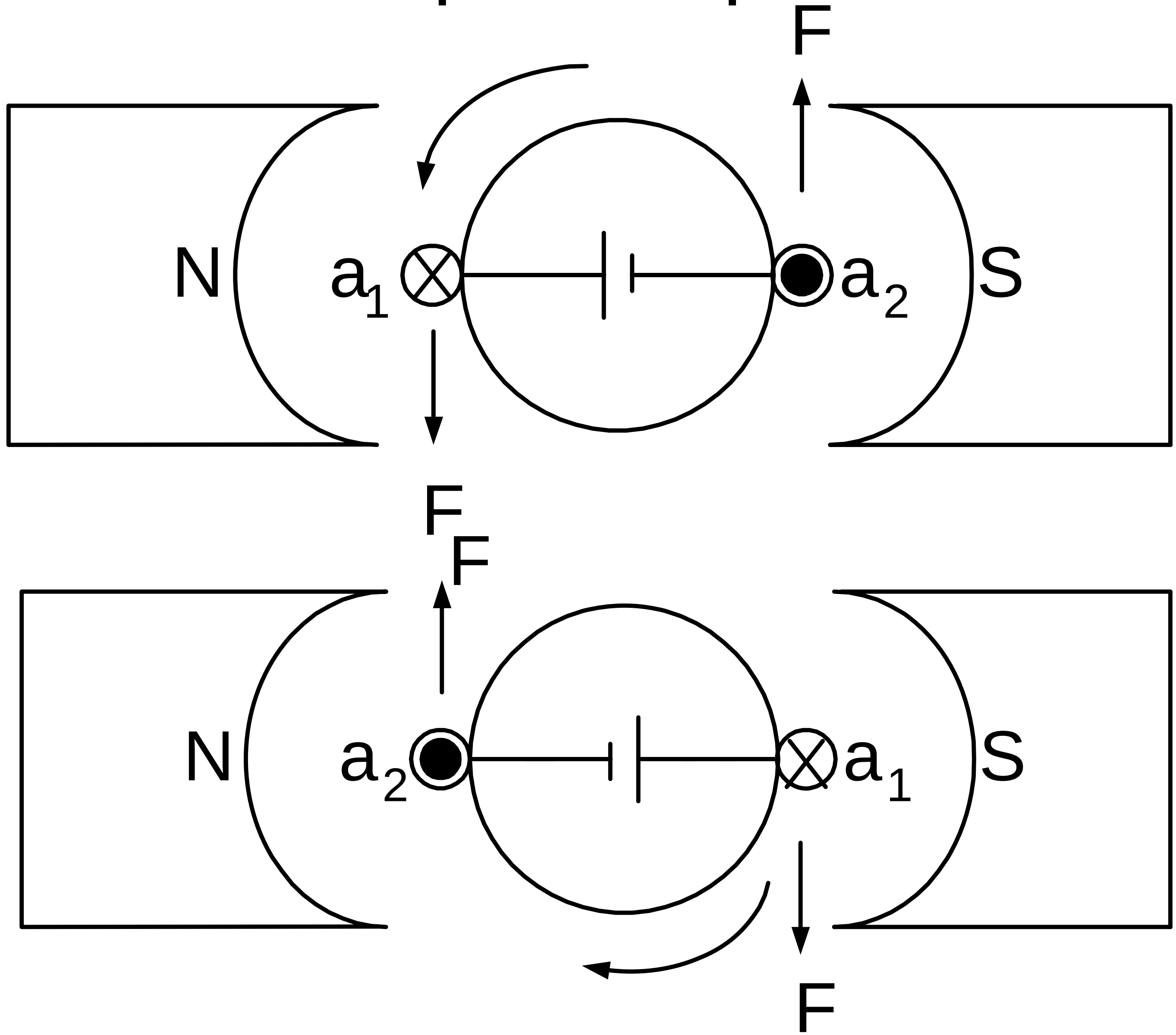
Armature Conductor



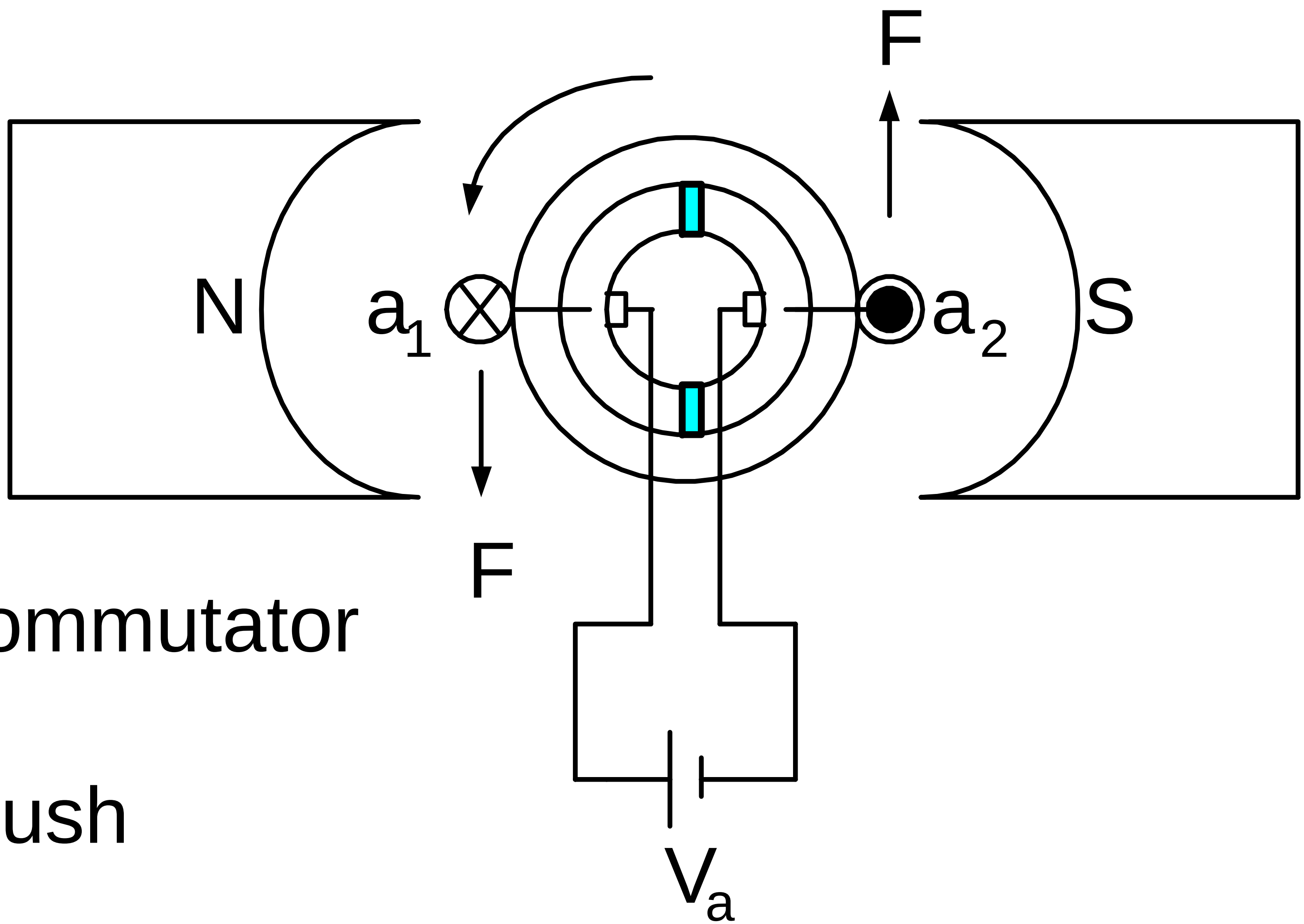
DC M/C : Principle of Operation



DC M/C : Principle of Operation

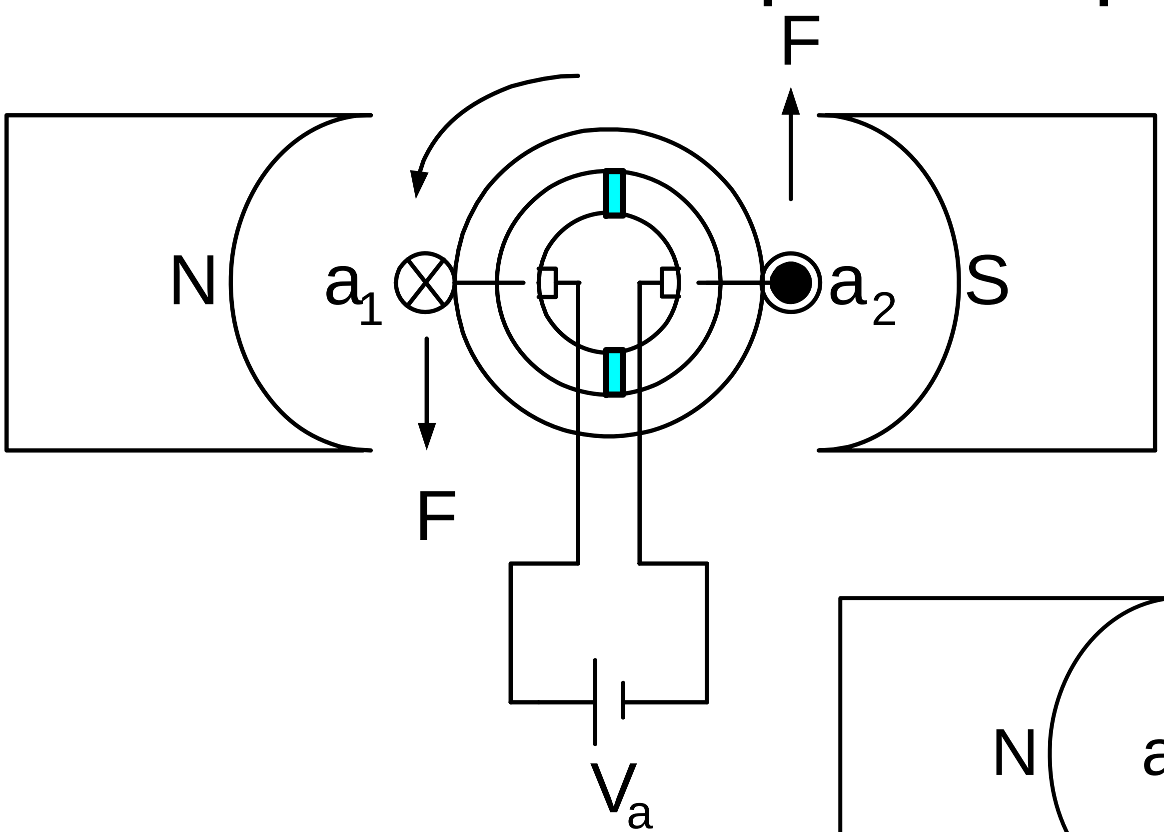


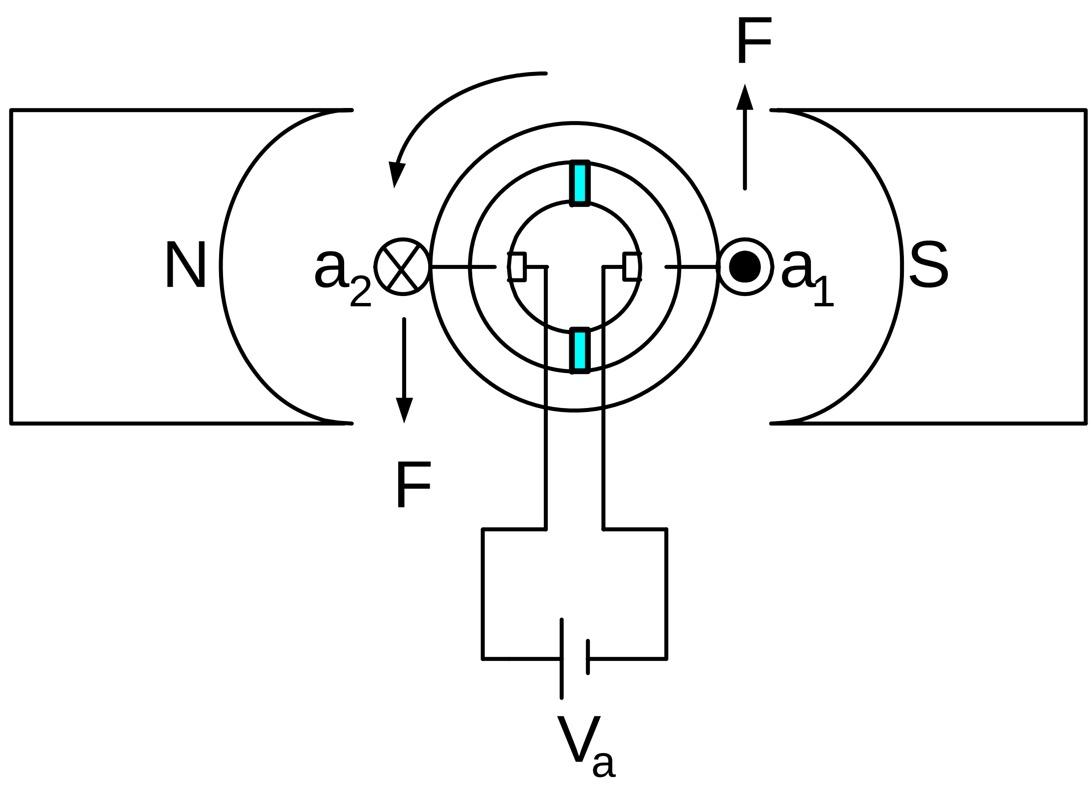
DC M/C : Principle of Operation



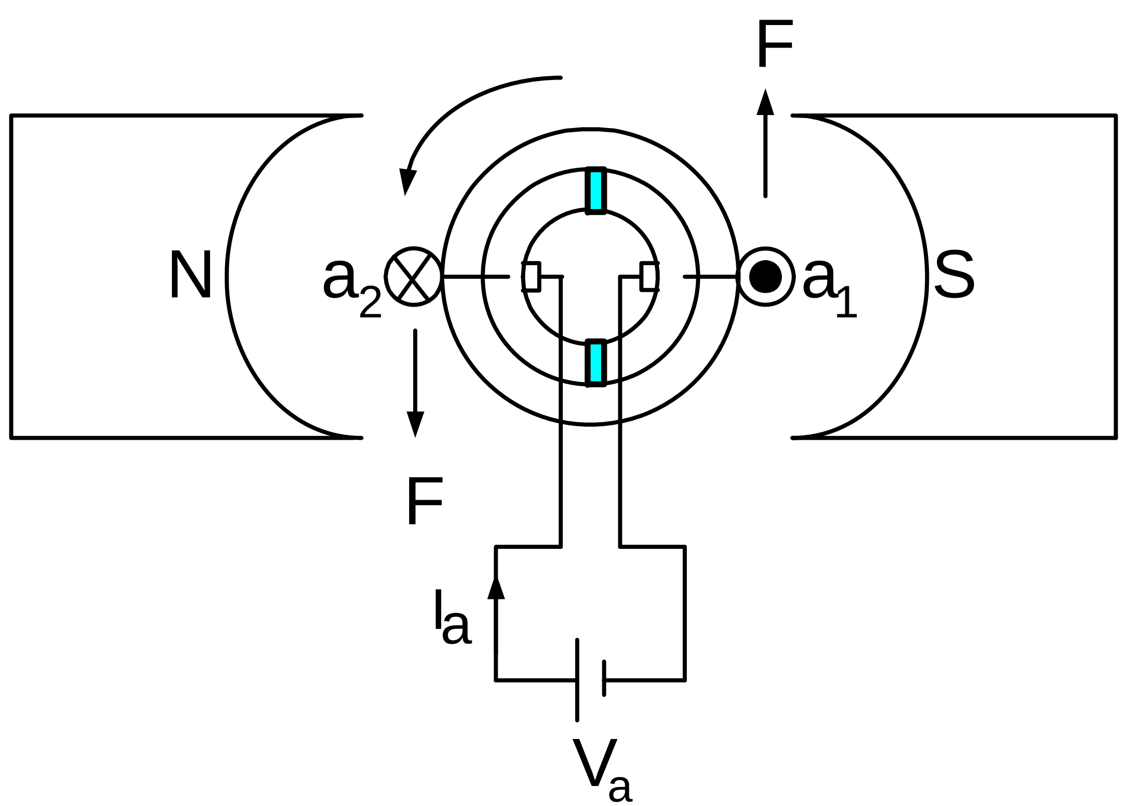
Commutator
&
Brush

DC M/C : Principle of Operation





DC M/C : Principle of Operation



$$F = BIL\sin\theta$$

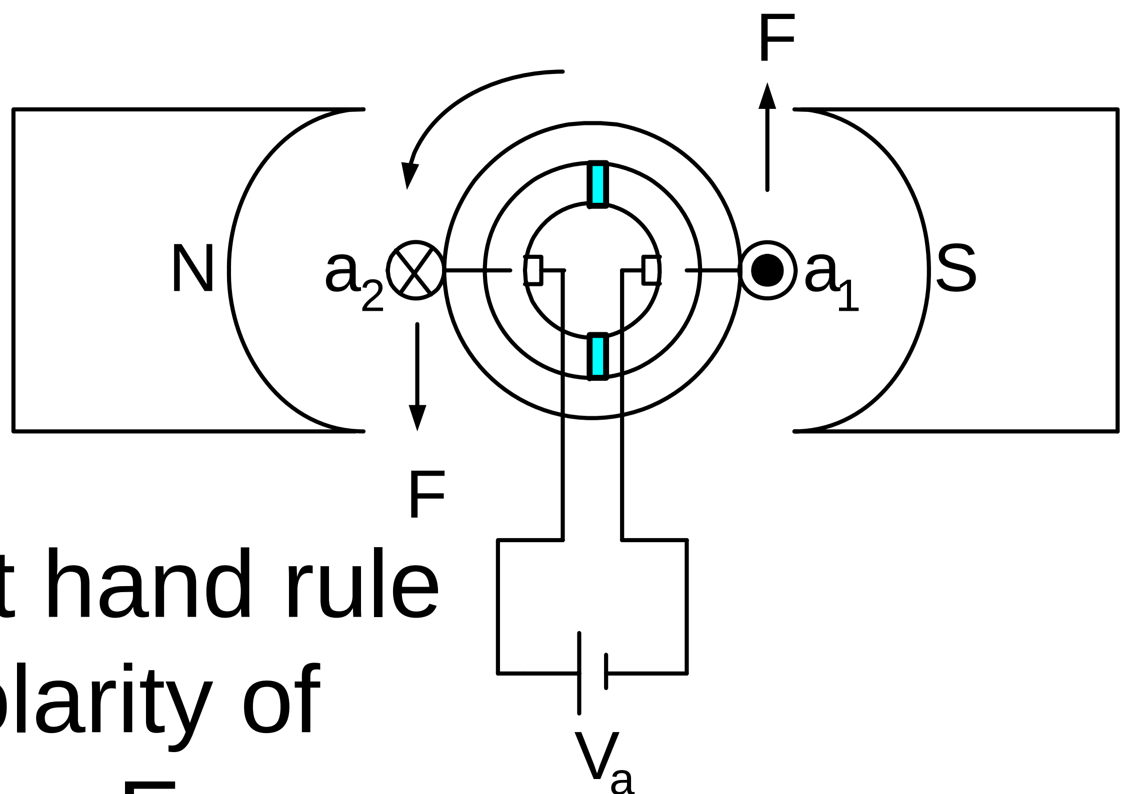
$$\theta \simeq 90^0$$

$$T \propto \phi I_a$$

Contradiction from Faraday's Law

$$E_b = 2BLv\sin\theta$$

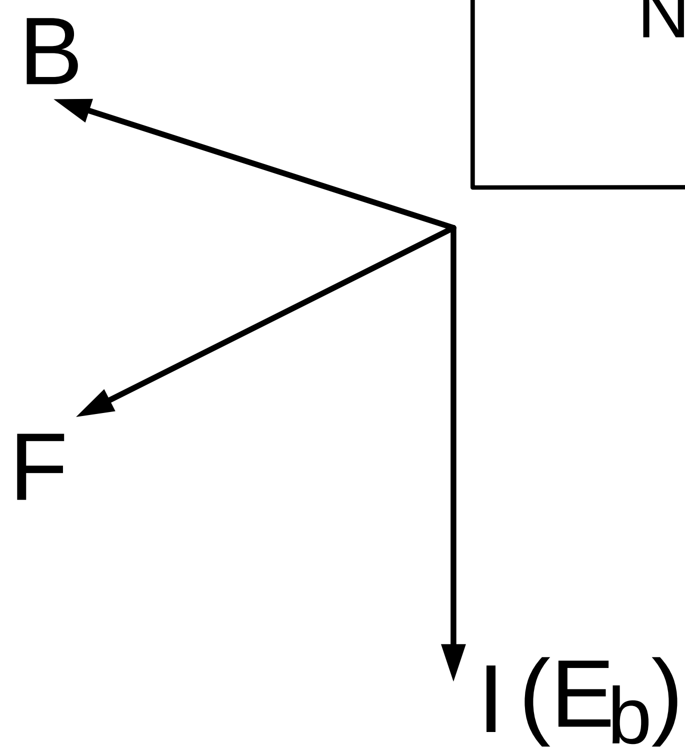
$$E_b \propto \phi\omega$$

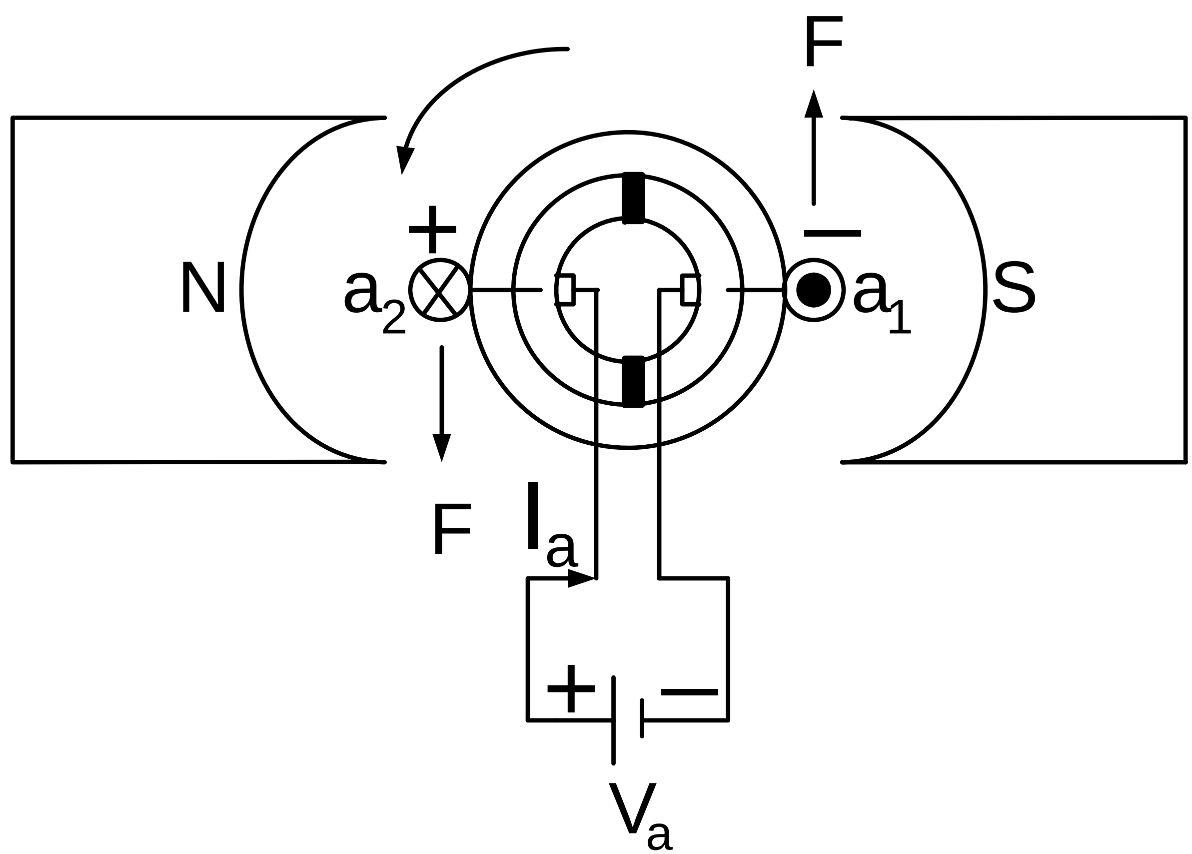


Fleming's right hand rule assigns the polarity of induced voltage, E

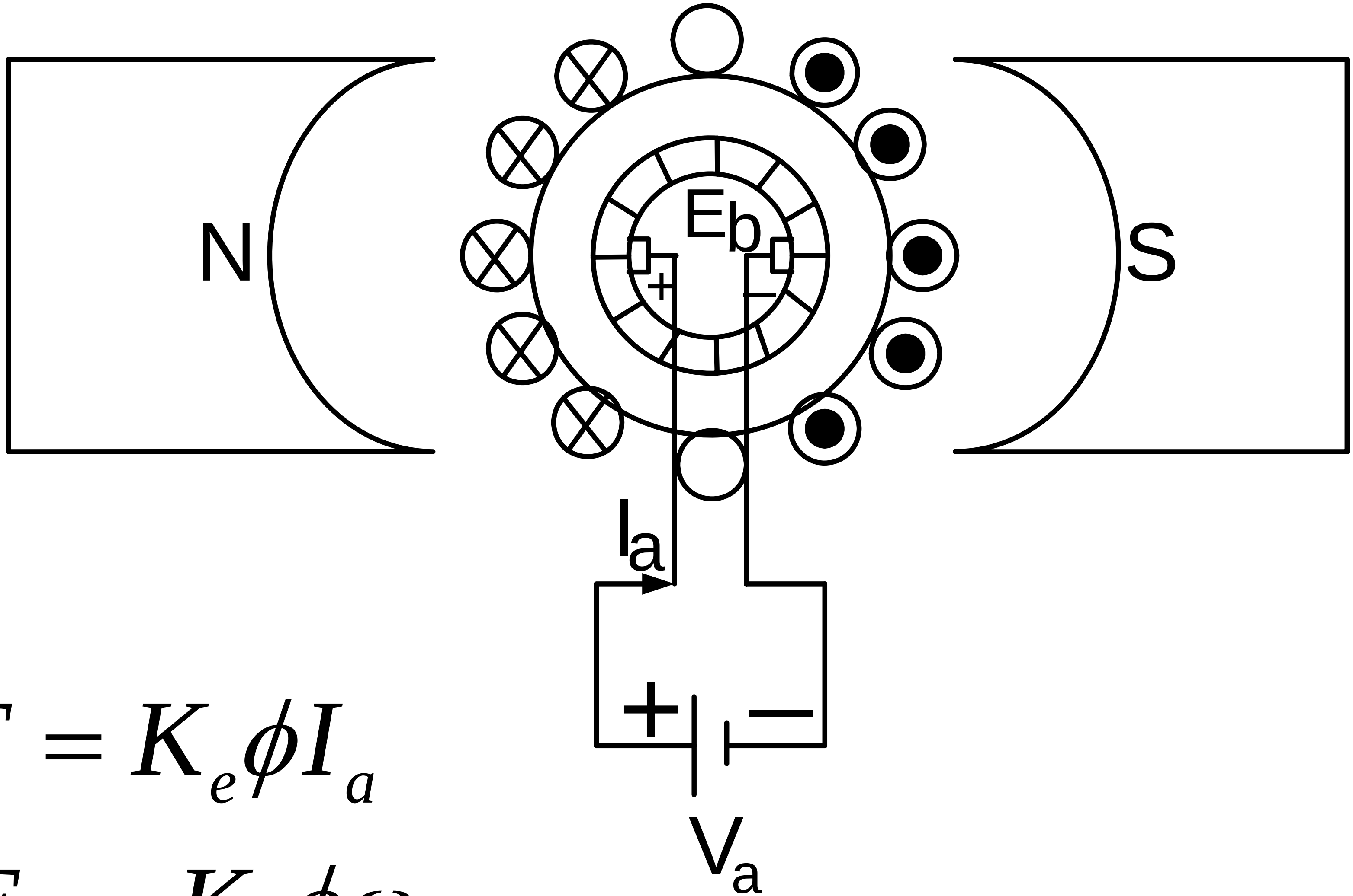
DC M/C : Principle of Operation

Fleming's right
Hand rule





A Realistic DC Machine



$$T = K_e \phi I_a$$

$$E_b = K_e \phi \omega$$

DC Machine: Steady state model and behaviour

Speed-Torque Characteristics

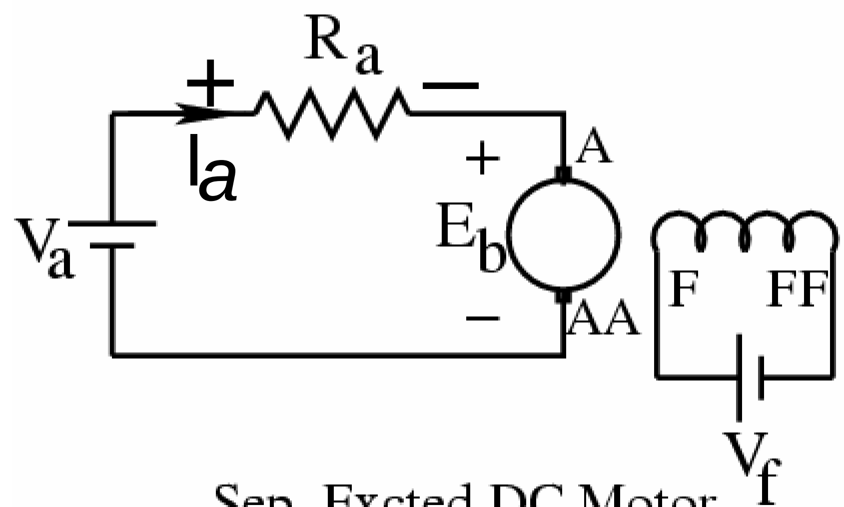
$$V_a = E_b + I_a R_a$$

$$E_b = K_e \Phi \omega$$

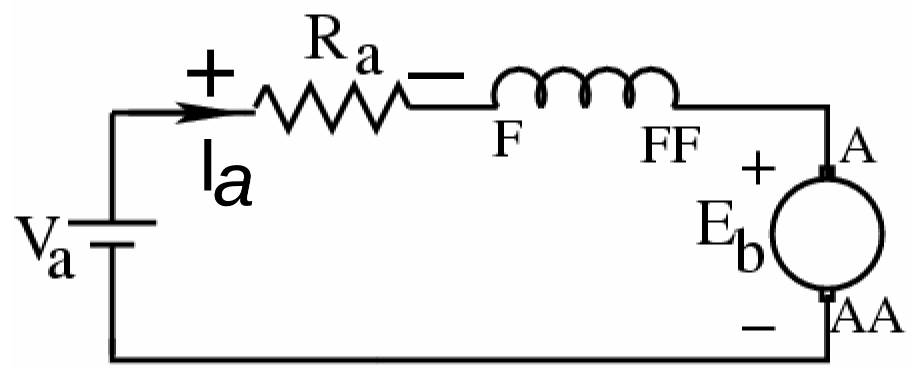
$$T = K_e \Phi I_a$$

$$\omega = \frac{V}{K_e \phi} - \frac{R_a}{K_e \phi} I_a$$

$$= \frac{V}{K_e \phi} - \frac{R_a}{(K_e \phi)^2} T$$



Sep. Excted DC Motor



DC Series Motor

DC Machine: Torque vs. speed Characteristics

For Sep. Excited Motor:

$$V_a = E_b + I_a R_a$$

$$E_b = K_e \Phi \omega$$

$$T = K_e \Phi I_a$$

$$\omega = \frac{V}{K_e \phi} - \frac{R_a}{K_e \phi} I_a$$

$$= \frac{V}{K_e \phi} - \frac{R_a}{(K_e \phi)^2} T$$

$$K_e \Phi = K$$

$$\omega = \frac{V_a}{K_e \phi} - \frac{R_a}{(K)^2} T$$

For Series Motor:

$$V_a = E_b + I_a R_a$$

$$E_b = K_e \Phi \omega$$

$$T = K_e \Phi I_a$$

$$\omega = \frac{V}{K_e \phi} - \frac{R_a}{K_e \phi} I_a$$

$$= \frac{V}{K_e \phi} - \frac{R_a}{(K_e \phi)^2} T$$

$$\Phi = K_f I_a$$

$$\omega = \frac{V_a}{\sqrt{K_e K_f}\sqrt{T}}$$

$$- \frac{R_a}{K_e K_f}$$

Speed – Torque Characteristic