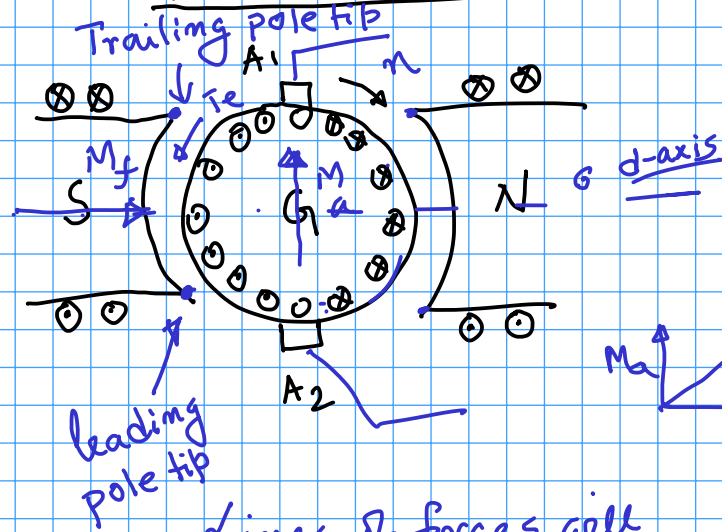
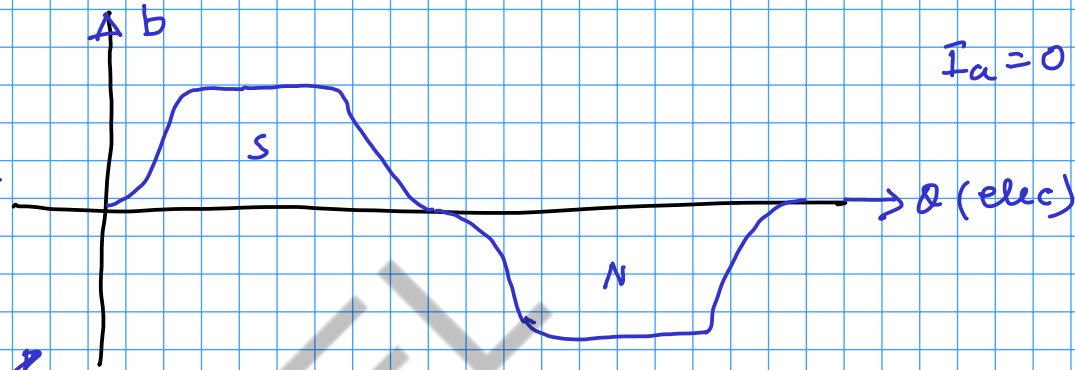
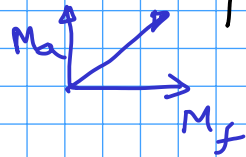


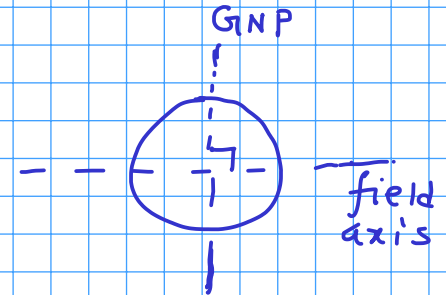
dec-71

Armature Reaction

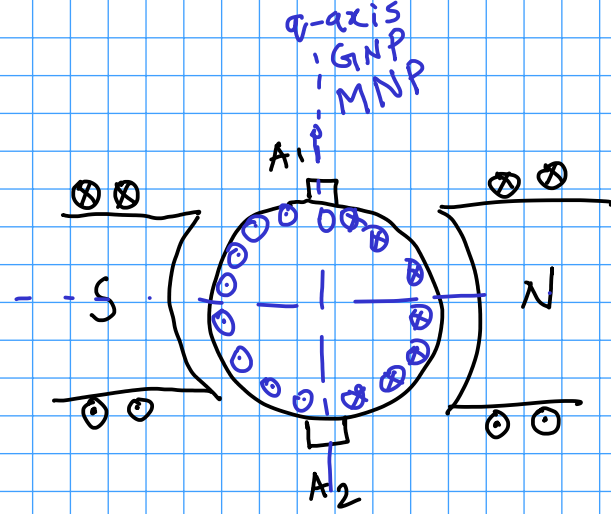


• with

Lines of forces will be concentrated under Trailing pole half

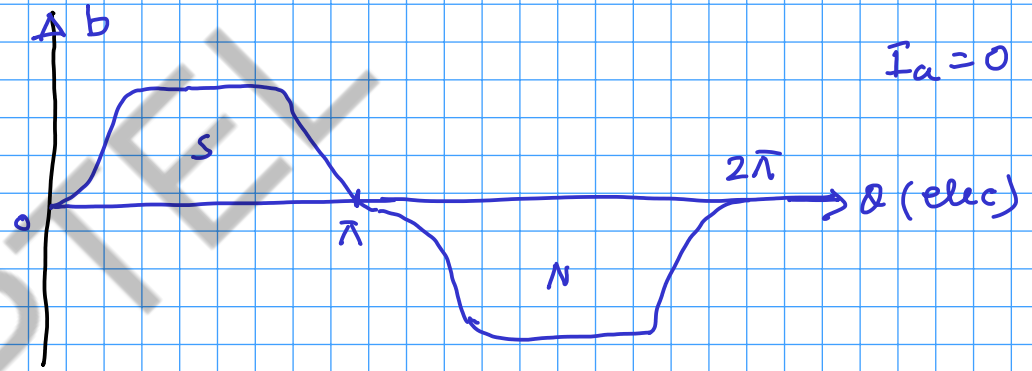


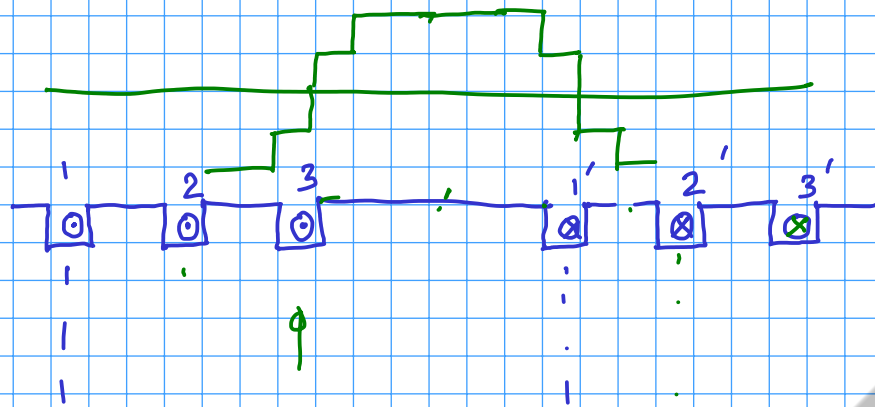
GNP : Geometric Neutral plane is along q-axis i.e., $\perp$ to field axis
MNP : Magnetic neutral plane where no magnetic field is present



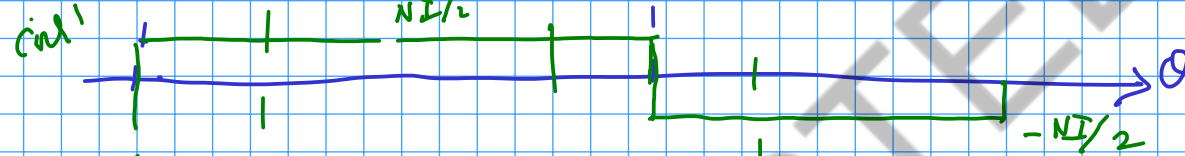
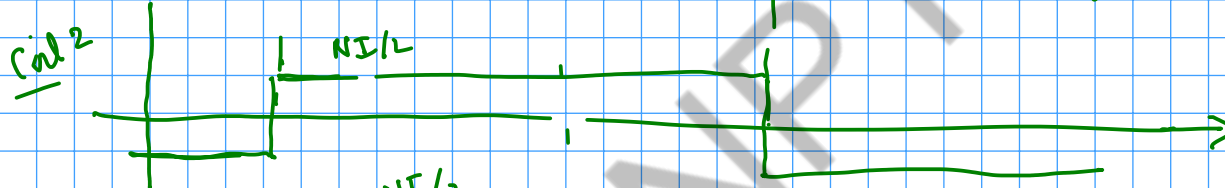
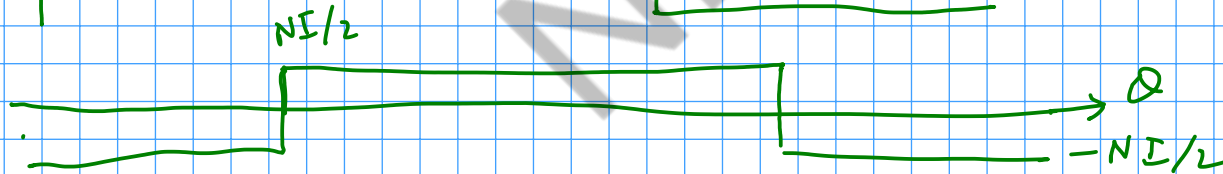
when $I_a \neq 0$

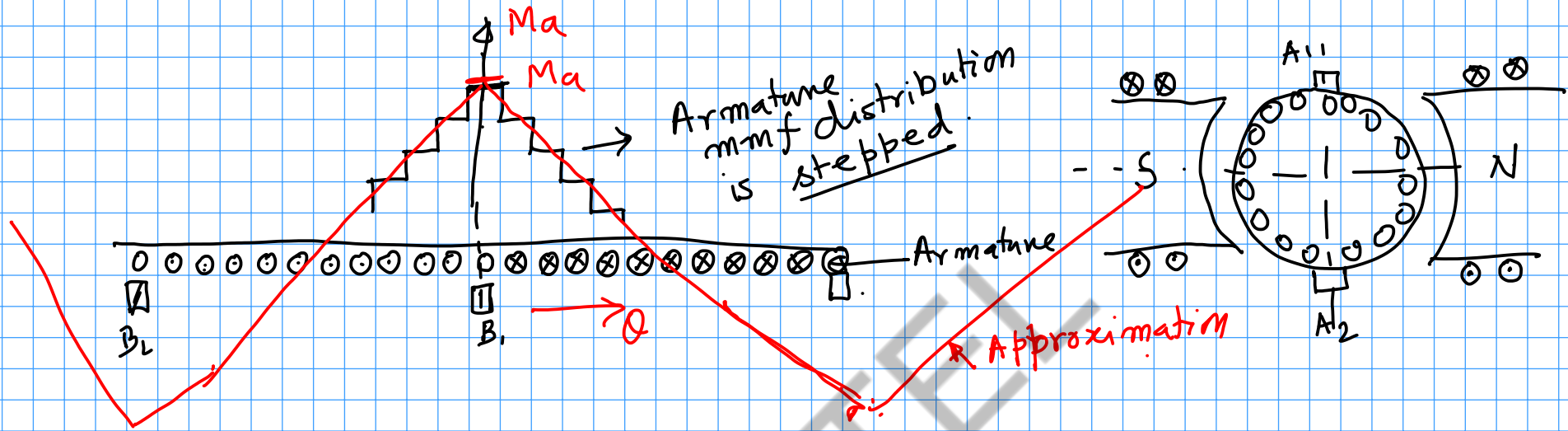
when $I_a = 0$: GNP & MNP coincide

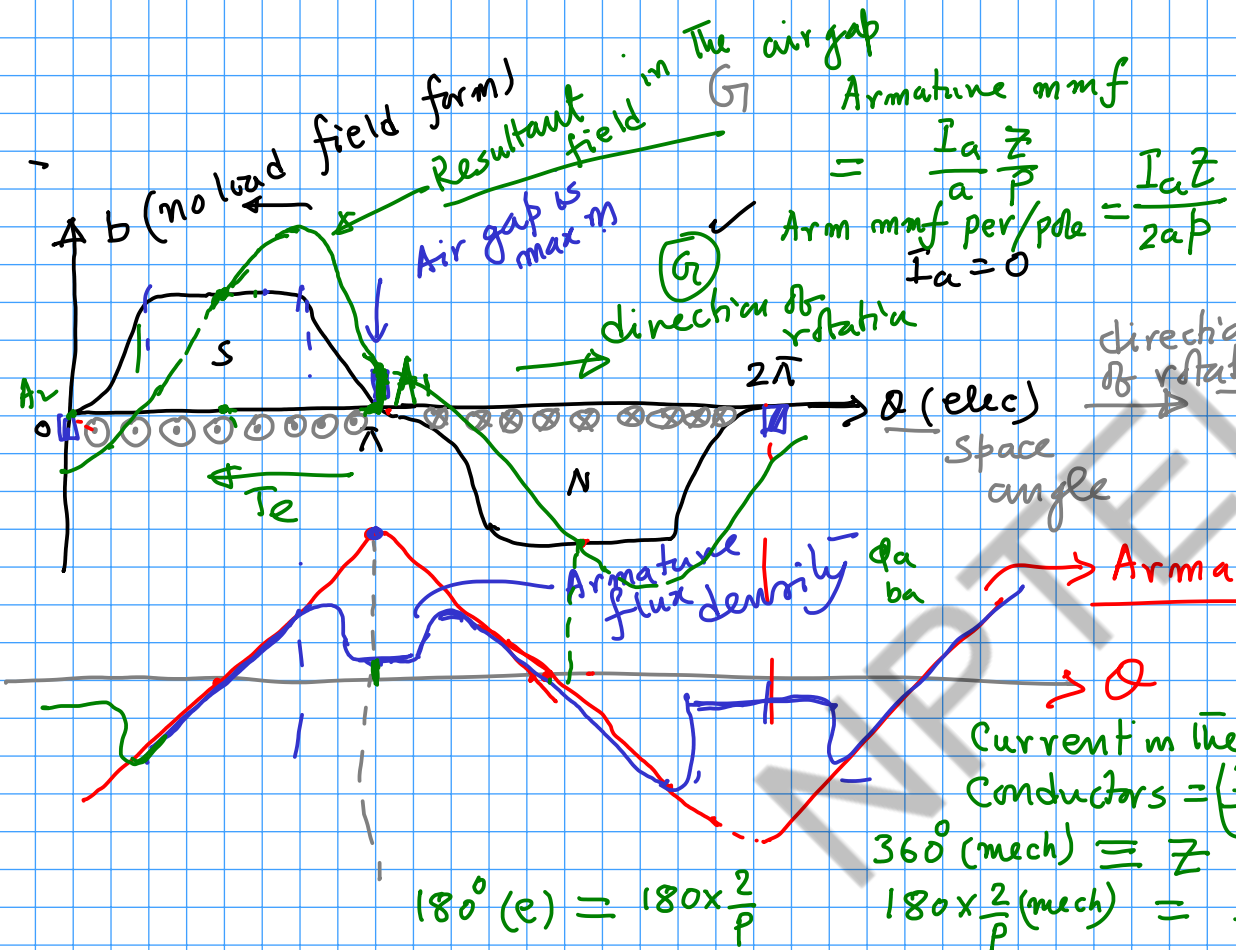
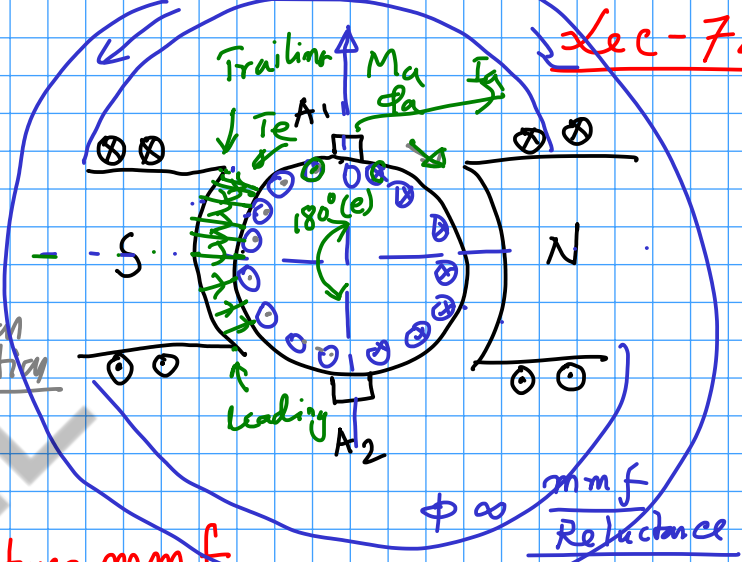




developed
diagram, $\frac{NI}{2}$







Armature mmf

Armature mmf per pole

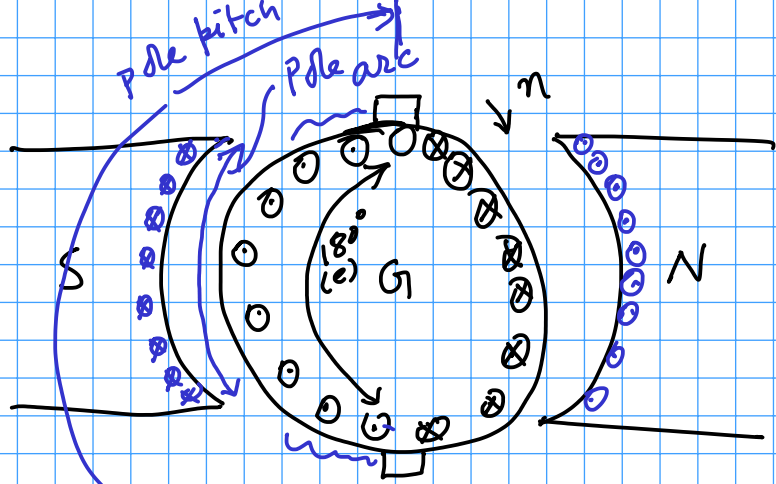
Let $P = \text{no. of poles}$
 $a = \text{no. of parallel paths in armature}$
 $Z = \text{total number conductors in the armature}$

Current in the conductors $= \left(\frac{I_a}{a} \right)$

$$360^\circ (\text{mech}) \equiv Z$$

$$180 \times \frac{2}{P} (\text{mech}) = \frac{Z}{360} \times \frac{180 \times 2}{P} = \frac{Z}{P}$$

$$180^\circ (e) = 180 \times \frac{2}{P}$$



2 pole representation
of a p-pole m/c.

Compensating winding

$$\frac{I_a Z}{2ap} \times \frac{\text{Pole arc}}{\text{pole pitch}} = I_a N_{\text{comp}}$$

Armature mmf per pole?

$$Z = \text{total conductors}$$

$$180^\circ(e) = 180 \times \frac{2}{p} (\text{mech})$$

$$360^\circ (\text{mech}) \equiv Z$$

$$\text{no. of conductors present in } 360^\circ \text{ mech} = Z$$

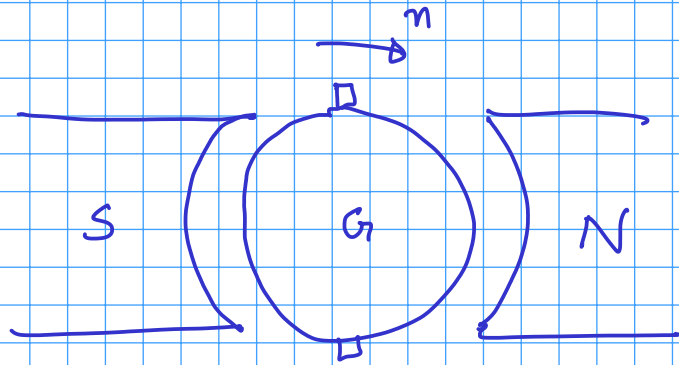
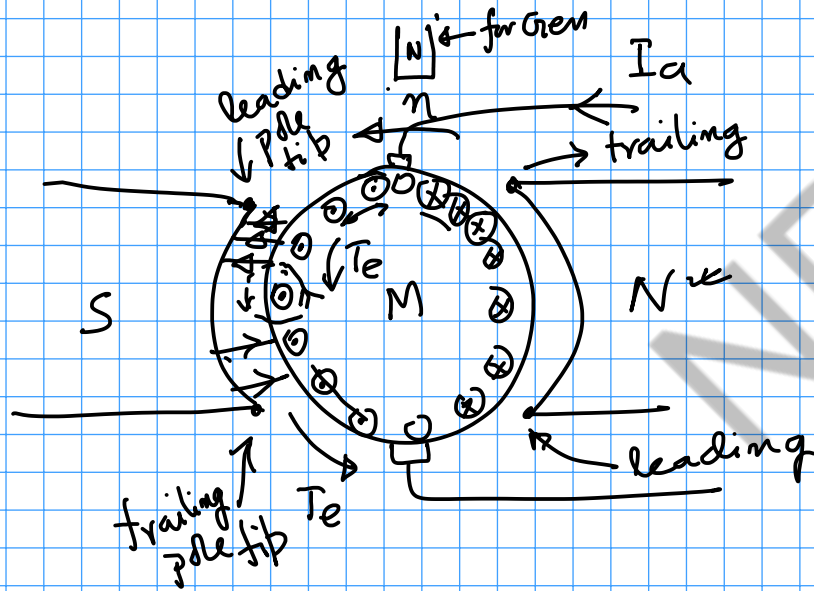
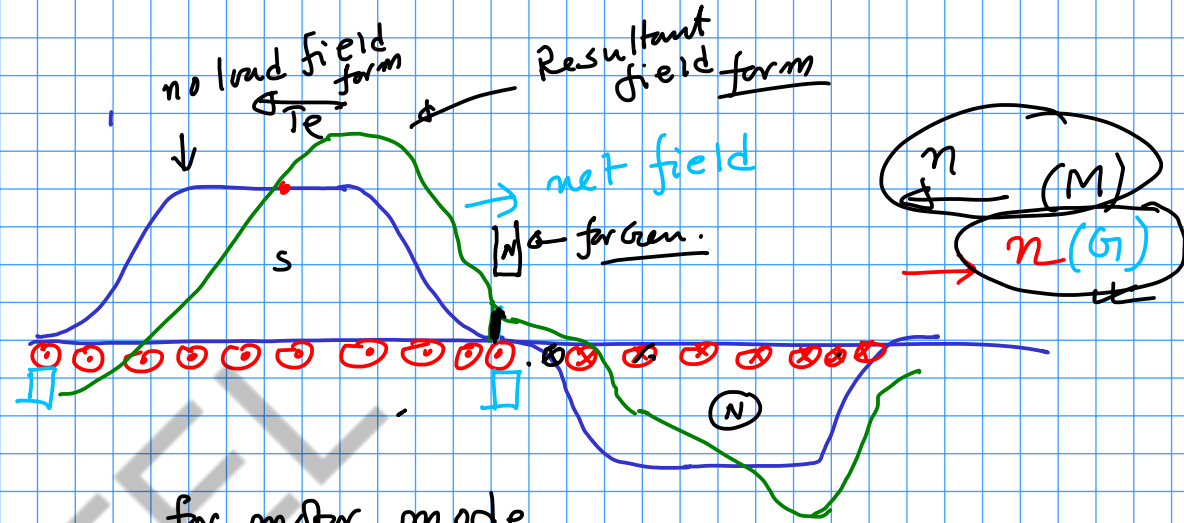
$$\therefore \text{no. of " " in } 180 \times \frac{2}{p} \text{ mech} = \frac{Z}{p}$$

$$\text{current in each conductor} = I_a/a$$

$$\text{Ampere conductors per pole} = \frac{I_a Z}{ap}$$

$$\therefore \text{Ampere turns per pole of armature} = \frac{I_a Z}{2ap}$$

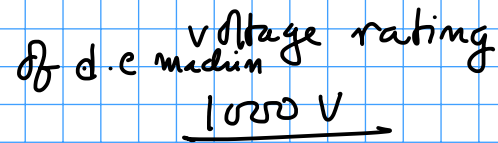
N_{comp} ✓



for motor mode
direction of rotation you reverse

In motor mode:-

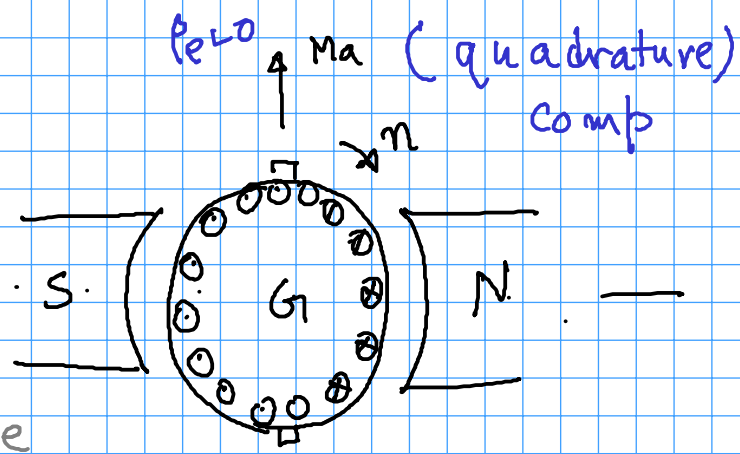
Resultant flux density will be concentrated in the leading pole tip & it rarefied in trailing pole tip.



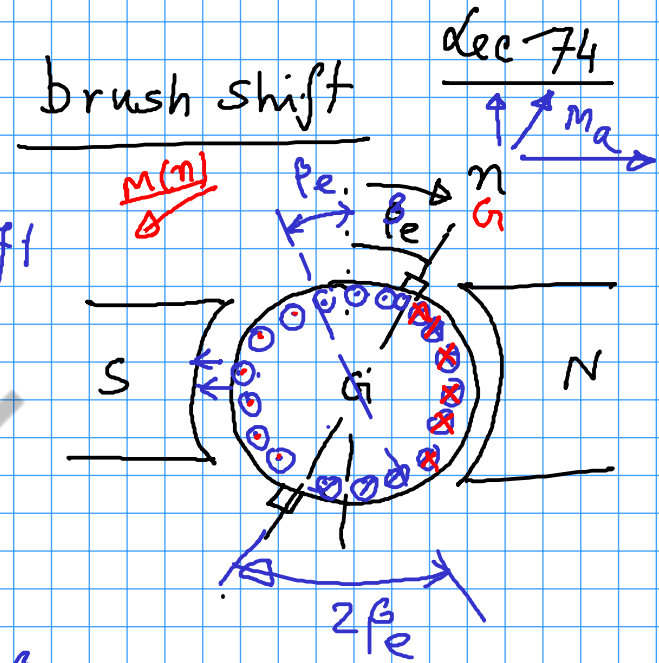
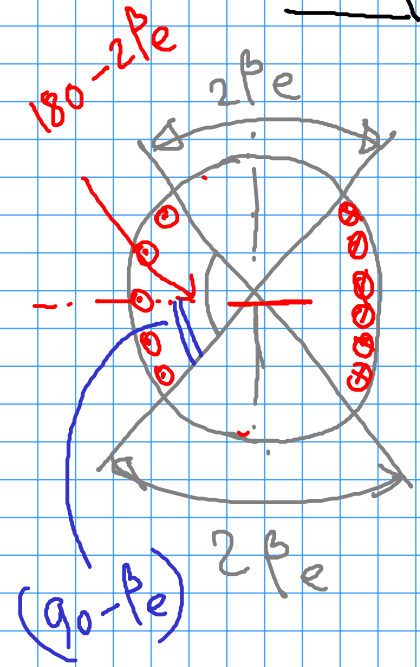
What should be the polarity of the interpole for motor mode

Answer is :- it should be same
same as main pole behind





β_e = brush shift angle in elec. deg



Armature mmf: Cross magnetisation

$$360^\circ (\text{mech}) \rightarrow Z$$

$$\left(4\beta_e \times \frac{2}{p}\right) \rightarrow \frac{Z}{360} \times \frac{8\beta_e}{p} = \frac{2Z\beta_e}{90p}$$

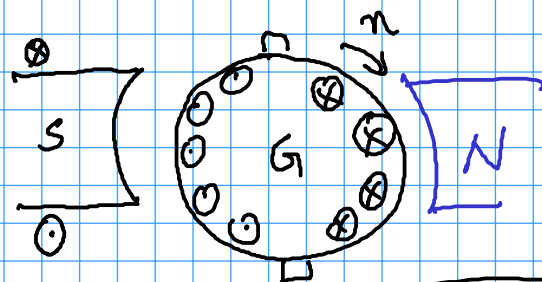
$$\text{turns} \rightarrow \frac{Z\beta_e}{90p}$$

$$AT_{\text{demag per pole}} = \frac{1}{2} \frac{I_a}{a} \frac{Z\beta_e}{90p} = \frac{I_a Z \beta_e}{180 ap}$$

$$AT_{\text{cross mag per pole}} = \frac{I_a Z}{180 ap} (90 - \beta_e)$$

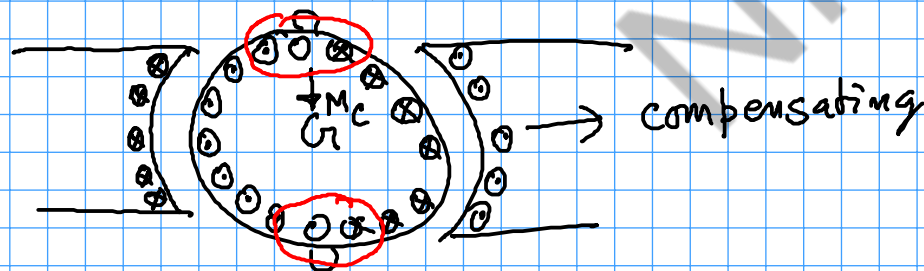
$$\text{Total AT/pole} = \frac{I_a Z}{180 ap} (90) = \frac{I_a Z}{2 ap}$$

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$$AT_{\text{cross/pole}} = \frac{I_a Z}{2ap} = \underline{1000}$$

interpole $AT_{\text{demagnetizing zero}}$

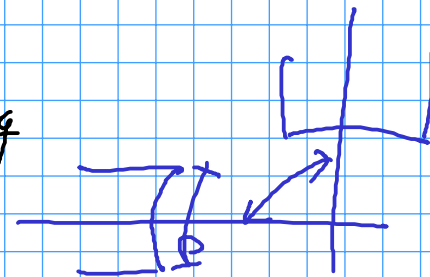


✓ Armature coil

✓ Field coil

Compensating coil

~~Inter~~ Interpole winding
brush shift



$$\frac{\text{Pole arc}}{\text{pole pitch}} = \underline{0.7}$$

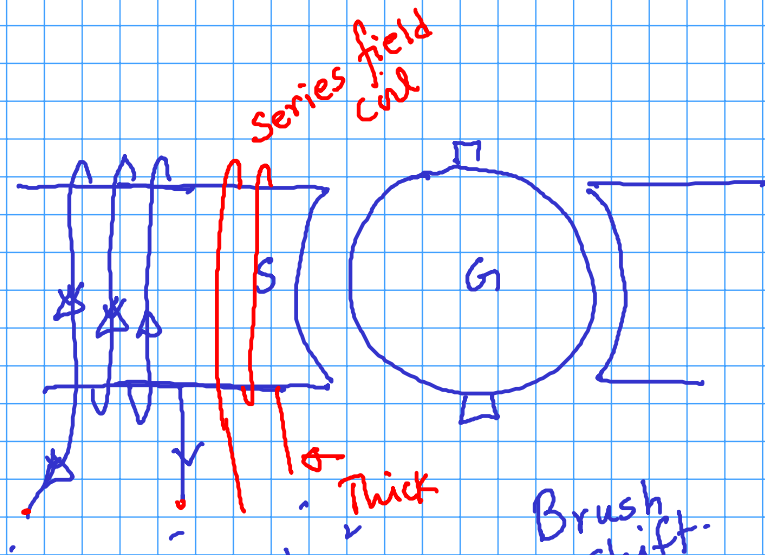
Compensating coil

will be able to

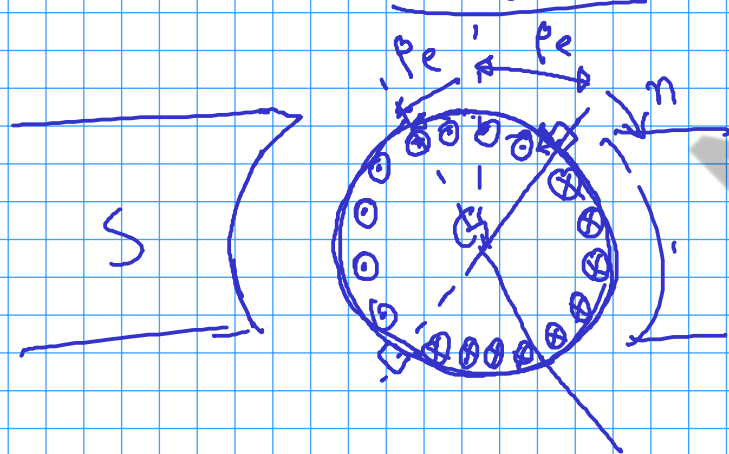
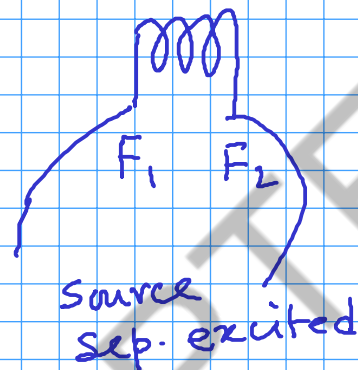
compensate for $0.7 \times 1000 \text{ AT}$

What about $= 700 \text{ AT}$
remaining $AT (1000 - 700)$

$= 300 \text{ AT}$ may be
compensated by interpole



Brush shift.



$$\frac{AT_d}{\text{pole}}$$

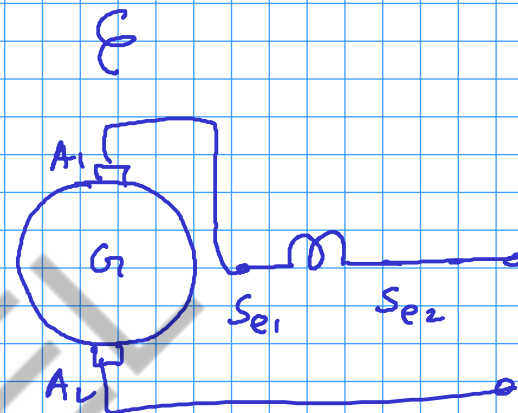
$$\uparrow \frac{AT_c}{\text{pole}}$$

$$\frac{I_a}{a} \frac{Z \beta_e}{180^\circ}$$

$$\frac{I_a}{a} \frac{Z}{180^\circ} (90^\circ - \beta_e)$$

$$\frac{AT_d / \text{pole}}{I_a} \rightarrow N_{se}$$

compensated by interpole.



Compound machine

Parker Smith book (9th Ed*)

Page 251

16, 17, 18

$$30^2 r_a = 417 \quad r_a = 0.46 \Omega$$

D.C. motors

Sec 75

separately excited motor

Shunt motor

Series motor

Assume $V_a = 220V$ (rated)

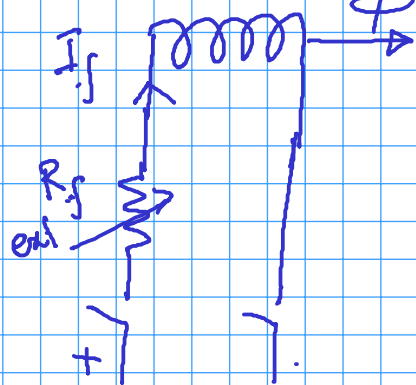
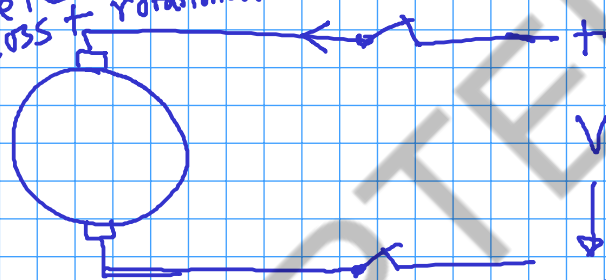
all the losses equal

P_{arm} 417W at starting
field cu loss: 417W

Total loss

$$= 6250 - 5000$$

$$= 1250W = \text{Arm cu loss} + \text{field cu loss} + \text{rotational loss}$$



V_a (d.c.)

200V, 5kW Net mech power output d.c.

Let $\eta = 80\%$

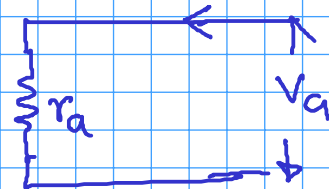
$$1. \text{ Total input} = \frac{5000}{0.8} W = 6.25kW$$

$$\frac{6250 - 417}{200} = 30A$$

$$\frac{V_f^2}{R_f} = 417$$

$$R_f = 96 \Omega \approx 100 \Omega$$

V_f (200V)



$$T_{starting} = \frac{V_a}{r_a}$$

(r_a) being very small
starting current will be high

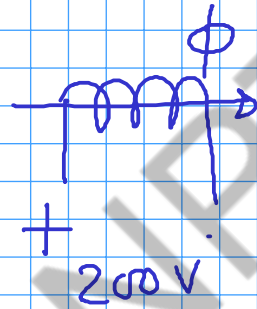
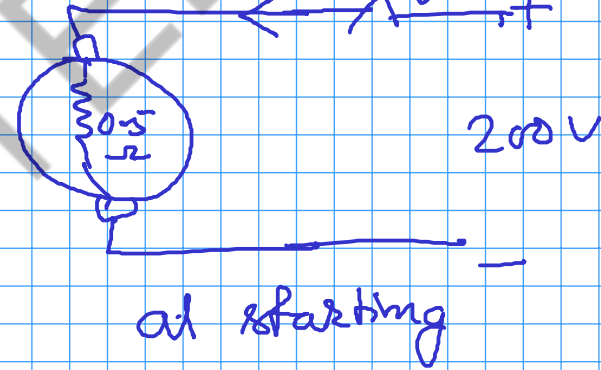
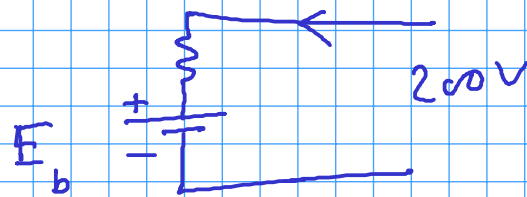
5 kW ^{output}, 200V, dc motor, sep. excited motor

Estimated values of $r_a \approx 0.5 \Omega$

$\frac{I_a}{I_{a \text{ rated}}} \approx 30$

field coil resistance $\approx 100 \Omega$

$I_{a \text{ starting}} \approx 400 \text{ A}$



5 Kw, 200 V D.C separately excited motor

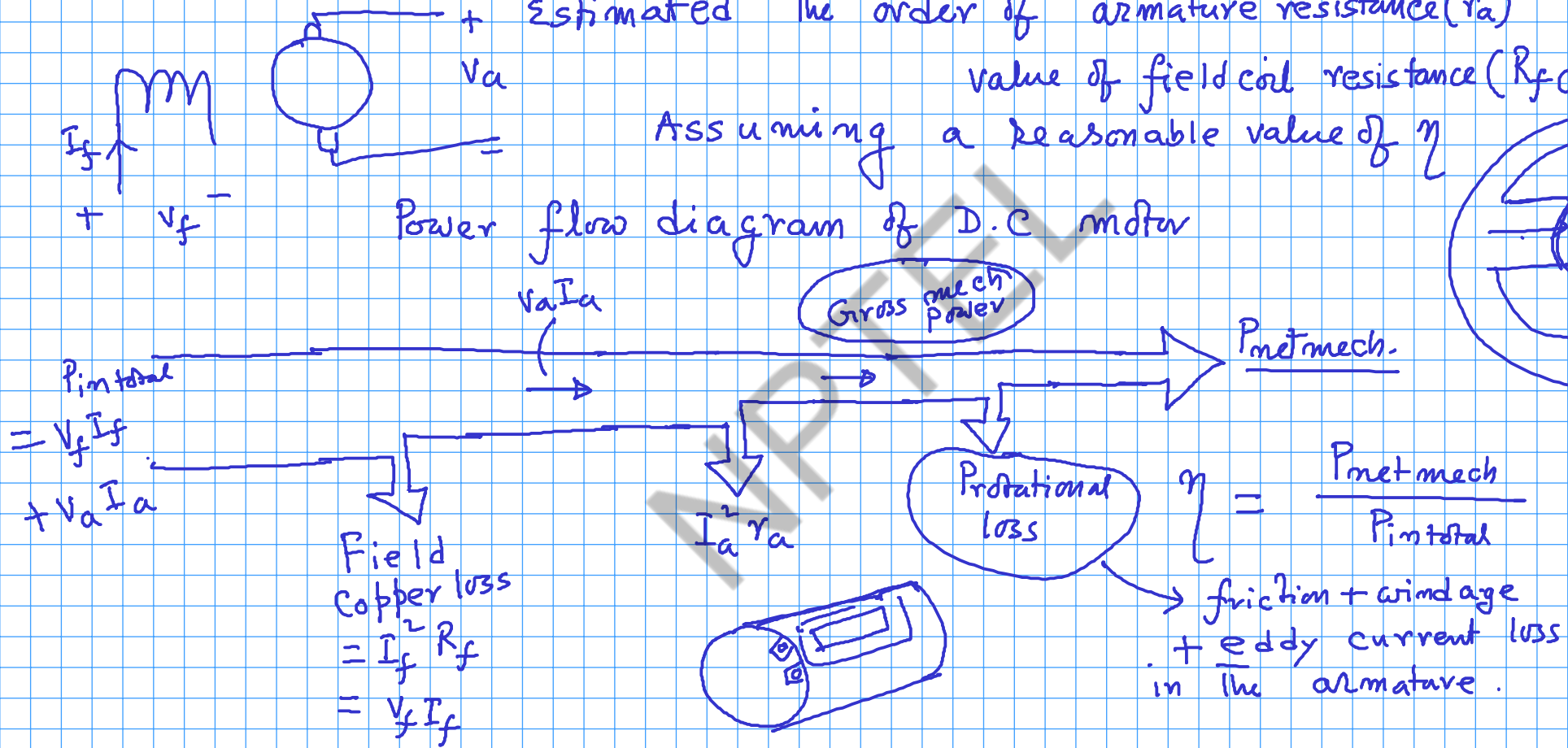
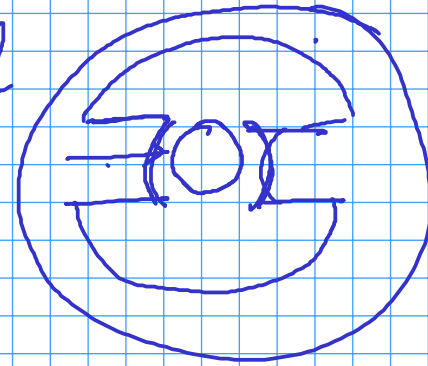
dec - 77

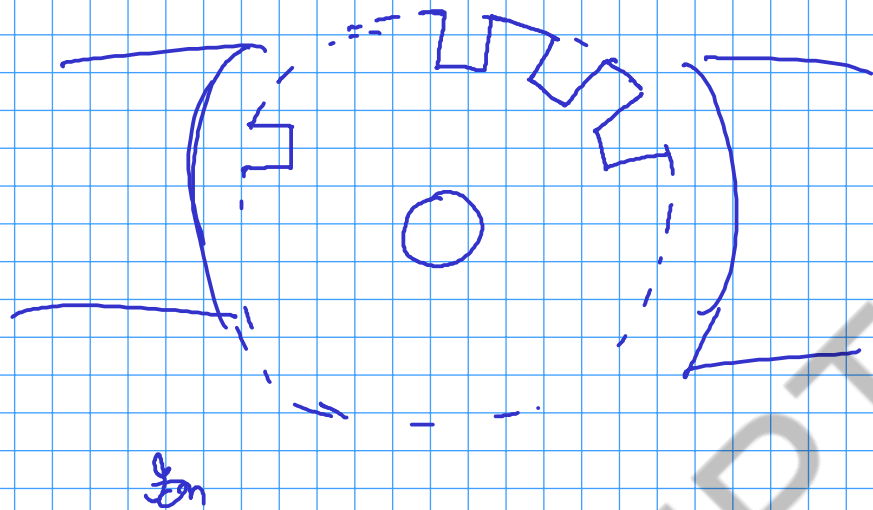
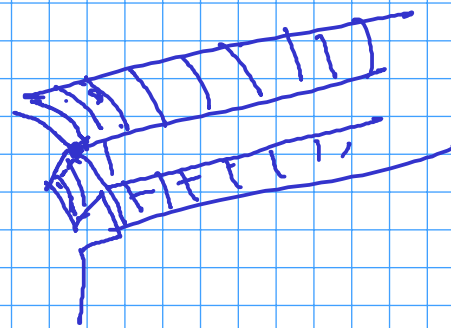
Estimated The order of armature resistance (r_a)

value of field coil resistance ($R_{f \text{ coil}}$)

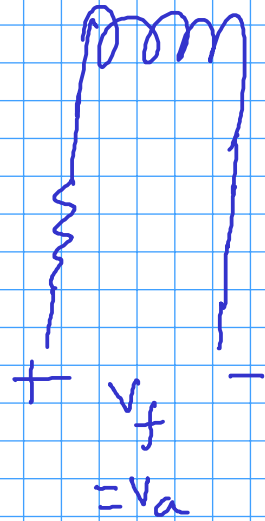
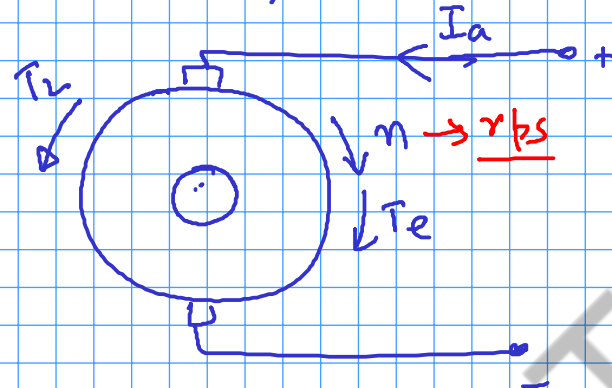
Assuming a reasonable value of η

Power flow diagram of D.C motor





Separately excited motor



$$\begin{aligned} \therefore P_{\text{gross mech power}} &= E_b I_a \\ T_{\text{gross torque dev. by the motor}} &= \frac{E_b I_a}{\frac{2\pi n}{a}} = \frac{1}{2\pi n} \frac{pZ\phi\pi I_a}{a} \\ &= \frac{pZ\phi I_a}{2\pi n a} = T_e \\ &= \frac{E_b I_a}{\frac{2\pi n}{a} \phi} = \frac{E_b I_a}{n \text{ rps.}} \end{aligned}$$

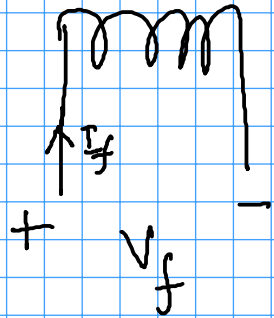
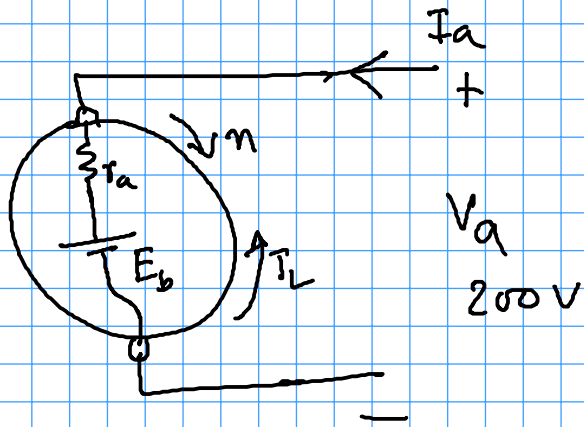
$$T_e = \frac{pZ}{2\pi a} \phi I_a = T_L$$

In the armature ckt.

$$V_a = E_b + I_a r_a$$

input power to armature $\rightarrow V_a I_a = E_b I_a + I_a^2 r_a \rightarrow \text{cu loss}$

$$P_{\text{net mech}} = E_b I_a - \text{rotational loss.}$$



$$\begin{aligned} 200 \text{ V} \quad r_a &= 5 \Omega \\ I_a &= 30 \text{ A} \\ 15 \text{ V} \end{aligned}$$

$$E_b = V_a - I_a r_a$$

$$I_a r_a < V_a$$

If $V_{a1} = 200 \text{ V}$ $\eta_1 = 1000 \text{ rpm.}$
 $I_a r_a$ drop is neglected

$I_{a1} = 15 \text{ A}$ $E_{b1} \approx 200 \text{ V}$
 torque is load constant $T_{L1} = T_{L2}$

Then back emf $E_b \approx V_a$
 If armature voltage is reduced to half $V_{a2} = 100 \text{ V}$

$$\frac{E_{b1}}{E_{b2}} = \frac{200}{100} = \frac{k\phi \eta_1}{k\phi \eta_2}$$

$$\therefore \eta_2 = \frac{1}{2} \times 1000 = 500 \text{ rpm.}$$

$$E_{b1} = 200 \text{ V}$$

$$E_{b2} = 100 \text{ V}$$

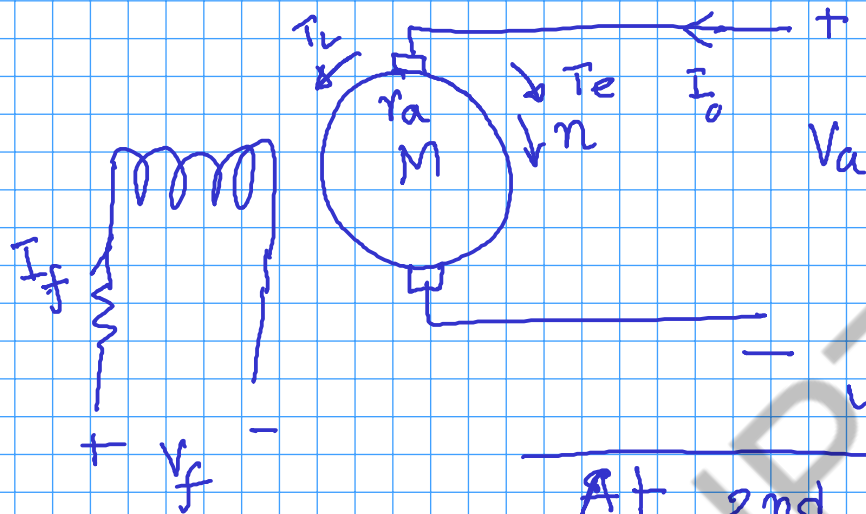
$$T_{e1} = k\phi \times 15 = T_{L1}$$

$$T_{e2} = k\phi I_{a2} = T_{L2}$$

$$\frac{T_{e1}}{T_{e2}} = \frac{15}{I_{a2}} = \frac{T_{L1}}{T_{L2}} = 1$$

$$I_{a2} = 15 \text{ A}$$

Seperately excited D.C motor



Let initial steady state
op. point

$I_{a1}, n_1, T_{L1}, I_{f1}, V_{a1}$

$$\checkmark E_{b1} = V_{a1} - I_{a1} r_a = k_G I_{f1} n_1 \quad \text{--- (1)}$$

$$\checkmark T_{e1} = k_T I_{f1} I_{a1} = T_{L1} \quad \text{--- (2)}$$

At 2nd steady operating point

$$E_{b2} = V_{a2} - I_{a2} r_a \quad \text{--- (3)} \quad I_{a2}, n_2$$

T_{L2}, I_{f2}, V_{a2}

$$T_{e2} = k_T I_{f2} I_{a2} = T_{L2} \quad \text{--- (4)}$$

① ÷ ③

$$\frac{E_{b1}}{E_{b2}} = \frac{V_{a1} - I_{a1} r_a}{V_{a2} - I_{a2} r_a} = \frac{k_{\phi} I_{f1} n_1}{k_{\phi} I_{f2} n_2}$$

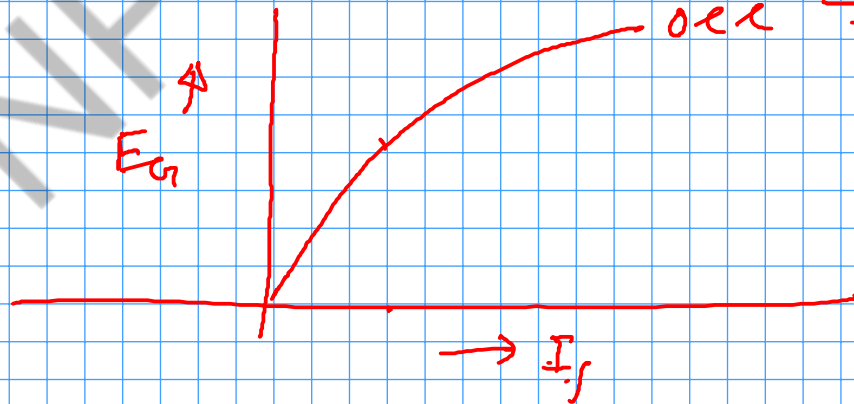
Neglected saturation
 $\phi \propto I_f$

② ÷ ④

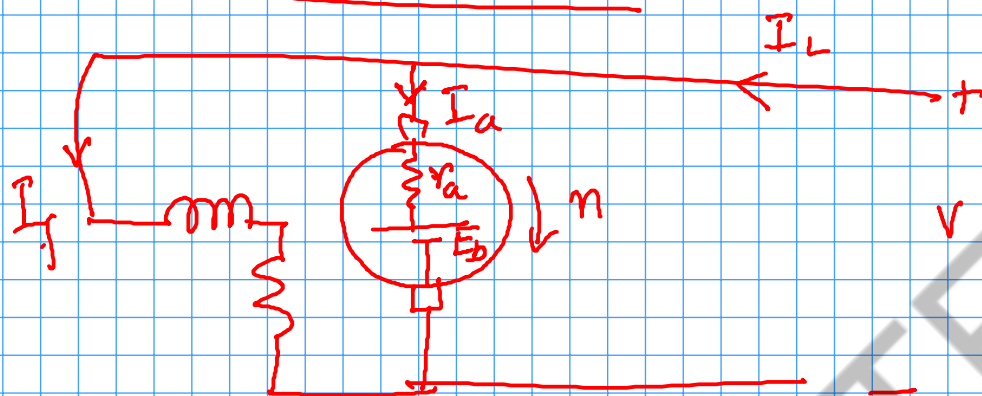
$$\frac{T_{e1}}{T_{e2}} = \frac{k_T I_{f1} I_{a1}}{k_T I_{f2} I_{a2}} = \frac{T_{L1}}{T_{L2}}$$

· If T_L is constant!
 $T_{L1} = T_{L2}$

· If $T_L \propto n^2$
 $\frac{T_{L1}}{T_{L2}} = \frac{n_1^2}{n_2^2}$



Shunt motor:



$$I_L = I_a + I_f$$

$$\left. \begin{aligned} E_b &= V - I_a r_a = K_G I_f n \\ T_e &= K_T I_f I_a = T_L \end{aligned} \right\}$$

$$V_1 = 200 \text{ V}$$

$$I_{f1} \searrow$$

$$n_1 = 1000 \text{ rpm}$$

$$E_{b1} = 200 \text{ V}$$

$$r_a \approx 0$$

$$V_2 = 50 \text{ V}$$

$$E_{b2} = 50 \text{ V}$$

$$I_{f2} = \frac{I_{f1}}{4}$$

$$\therefore \underline{n_2 = 1000 \text{ rpm}}$$

$$V = 200 \text{ V}$$

$$E_b \approx 200 \text{ V}$$

$$\frac{E_{b2}}{E_{b1}} = \frac{50}{200} = \frac{K_G I_{f2} n_2}{K_G I_{f1} n_1}$$

$$\text{or } \frac{1}{4} = \frac{I_{f2} n_2}{I_{f1} 1000} = \frac{1}{4} \frac{n_2}{1000}$$