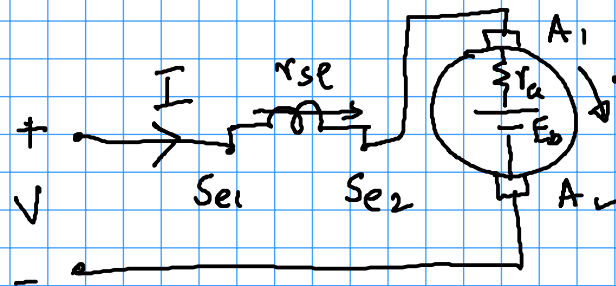


Series motor :-

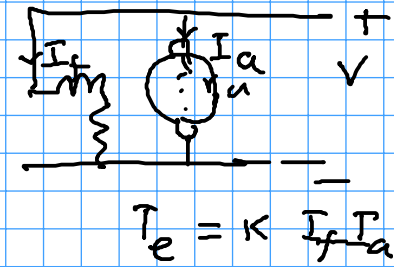


$\phi \propto I$ if saturation is neglected.

$$V = I(r_{se} + r_a) + E_b$$

$$E_b = k_g \phi n = k' I n$$

$$V = I(r_{se} + r_a) + k' I n$$

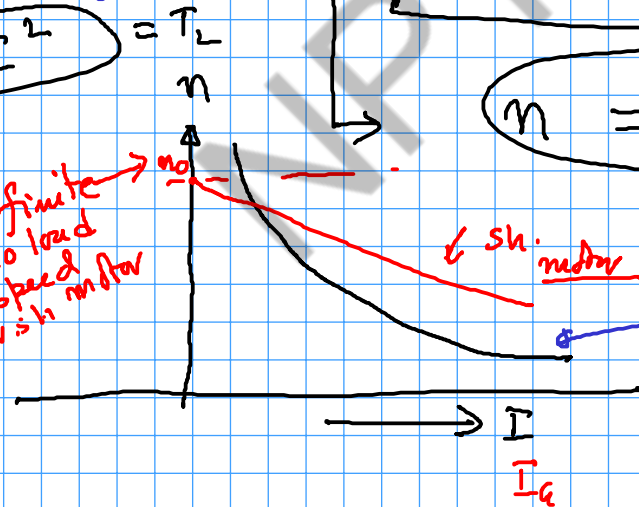


$$T_e = k_T \phi I$$

$$T_e = k_T I^2$$

$$T_L \approx 0$$

finite
no load
speed
for sh motor

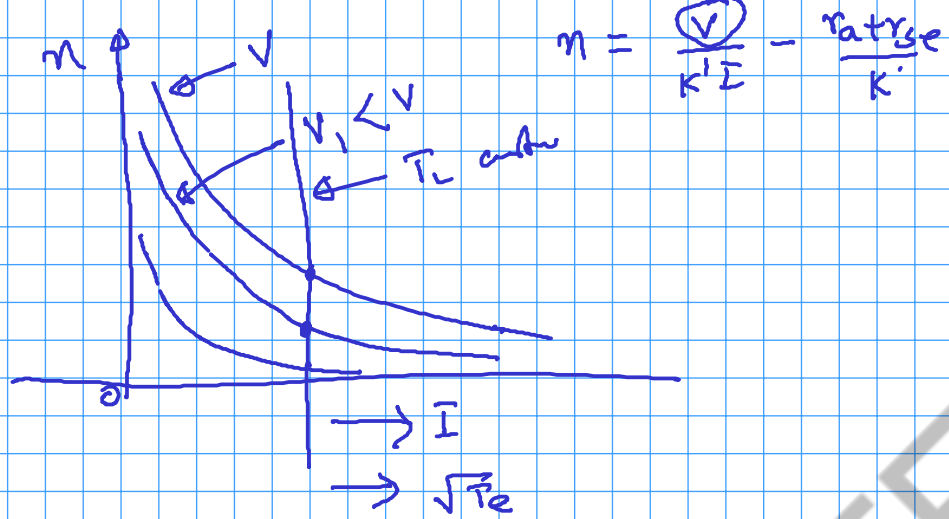


$$n = \frac{V}{k' I} - \frac{(r_a + r_{se}) I}{k' I}$$

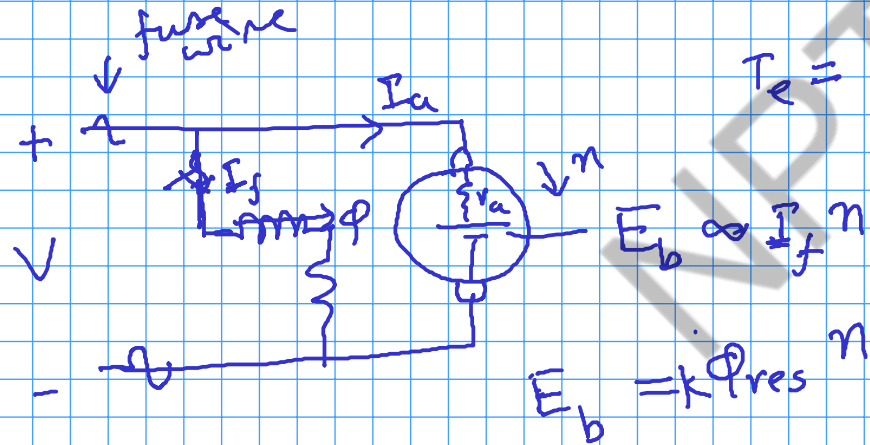
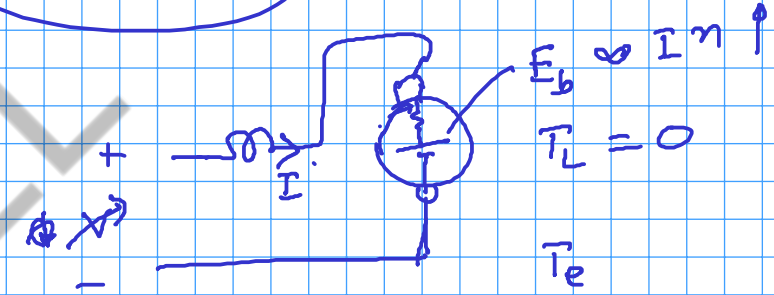
Small

$$n \propto \frac{1}{I}$$

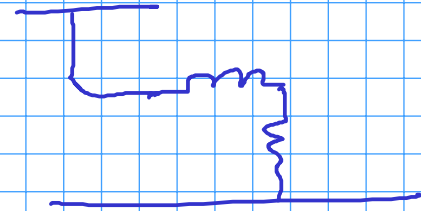
Series motor (no finite no load speed $\rightarrow$ infinite)
(degree of loading)



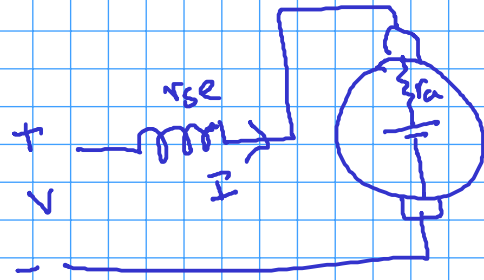
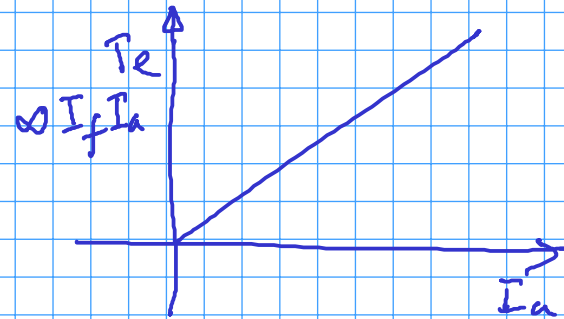
$T_e \propto I^2$
 $I \propto \sqrt{T_e}$



$I = 0$
 V is decreased to say V_1



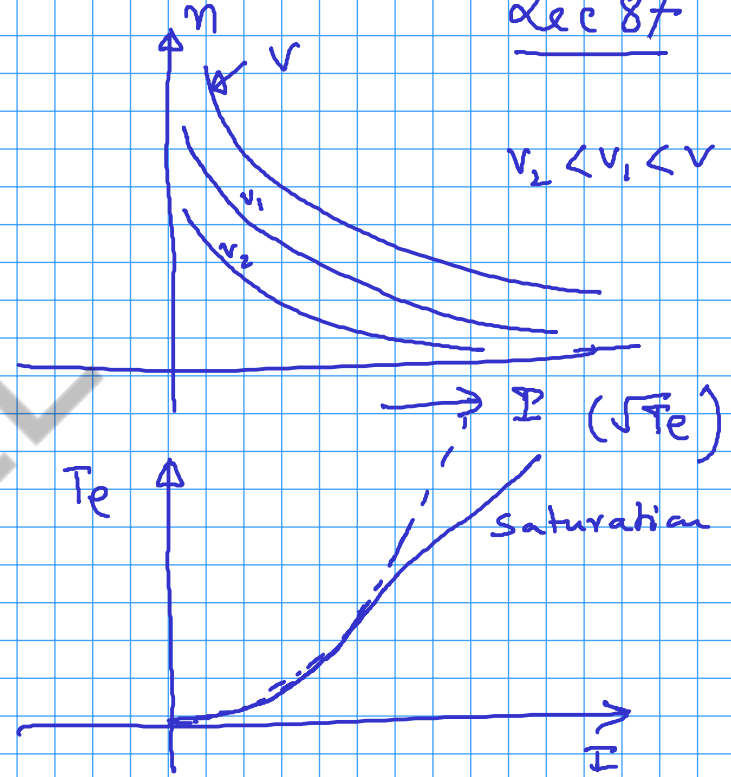
Series Motor



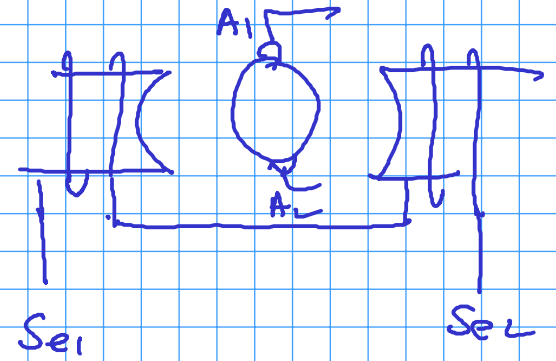
$$T_e \propto I^2$$

if saturation neglected

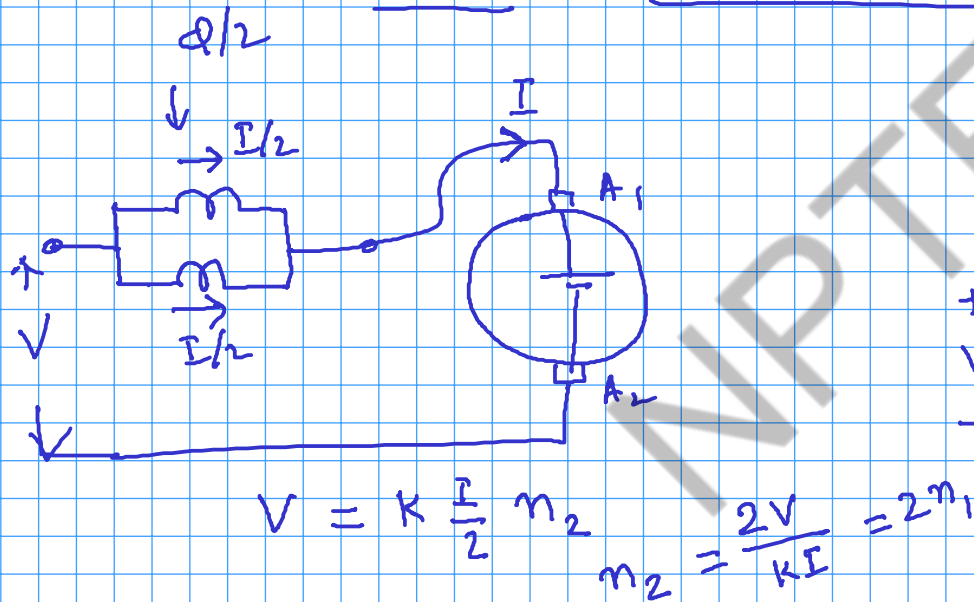
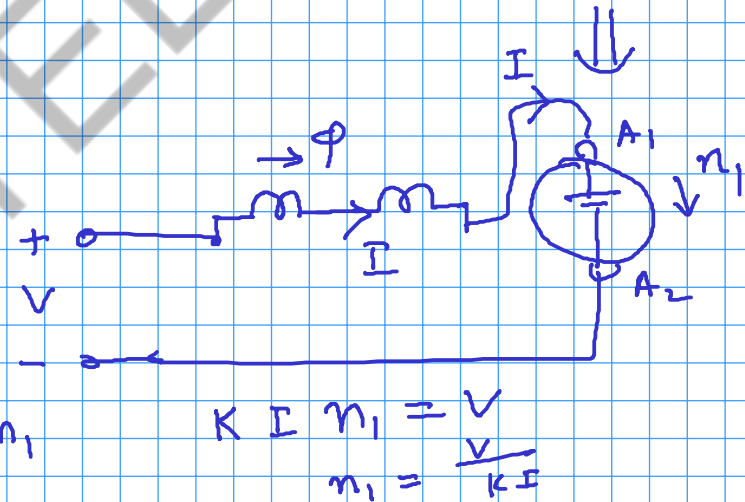
$$T_e \propto \Phi_f I_f$$



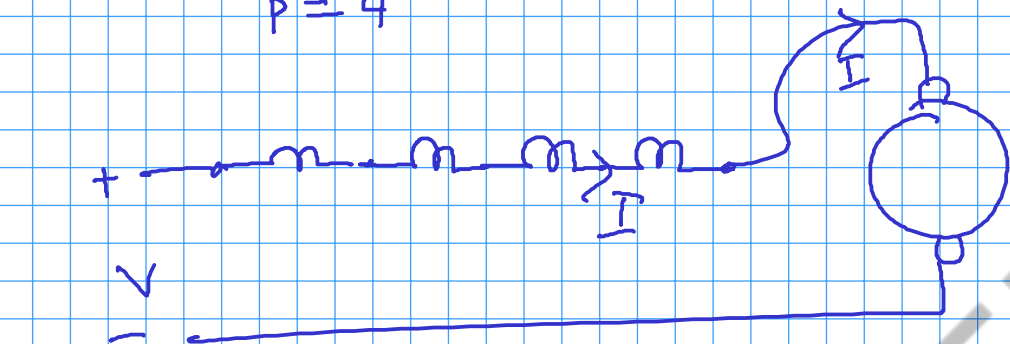
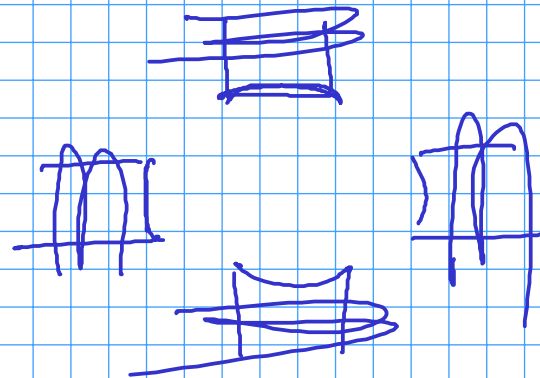
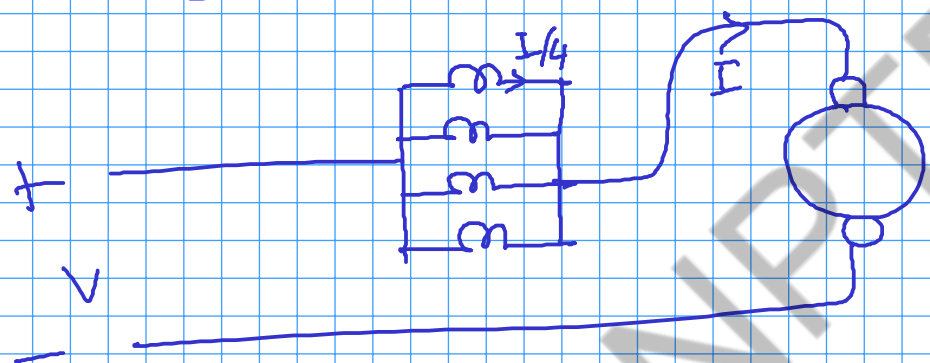
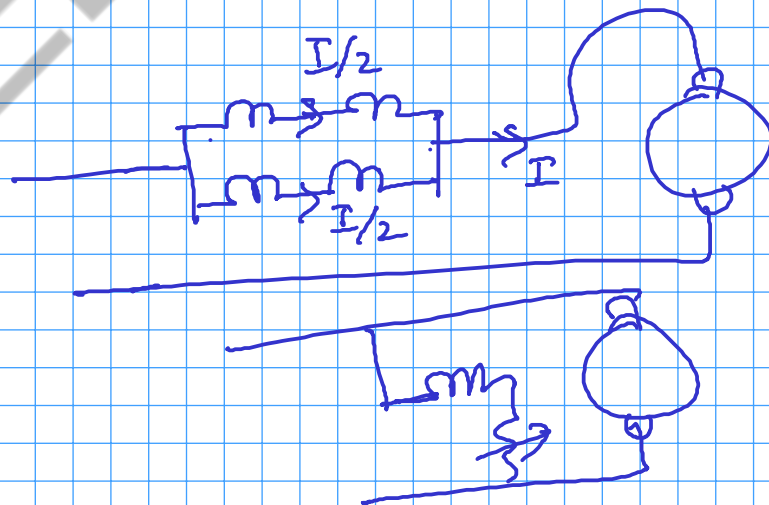
How to control field current in series motor?



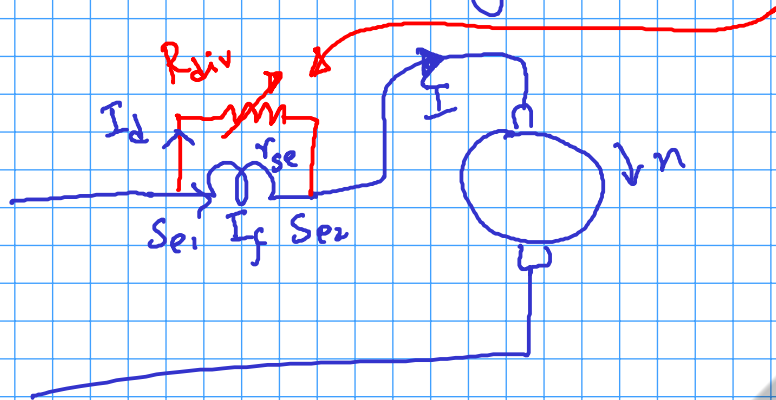
$p = 2$ Series motor



$$p = 4$$



field control of series motor
by using a diverter Resistance



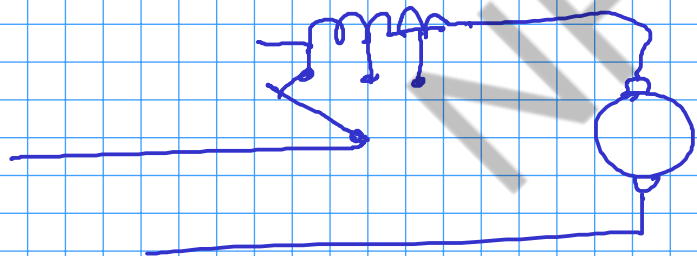
$$T_e \propto I I_f$$

$$E_b \propto I_f n$$

$$I_d = \frac{r_{se}}{r_{se} + R_{div}} I$$

$$I_f = \frac{R_{div}}{r_{se} + R_{div}} I$$

tap field-



Neglect Armature & field resistances
of a series motor

Saturation neglected

Case (i) T_L is constant

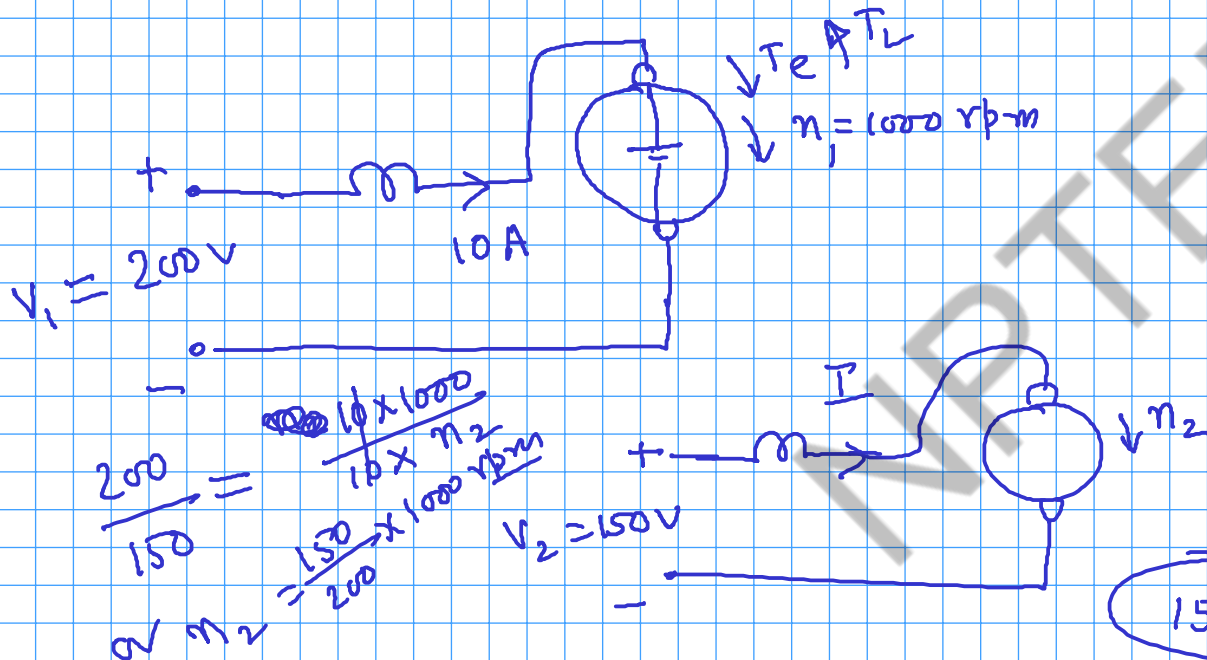
$$200 = K \times 10 \times 1000 \dots \textcircled{1}$$

$$T_{e1} = T_{L1} = \bar{K} 10^2 \dots \textcircled{2}$$

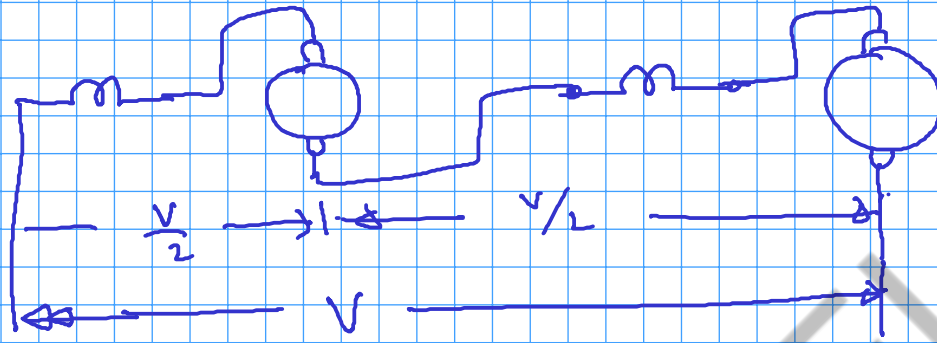
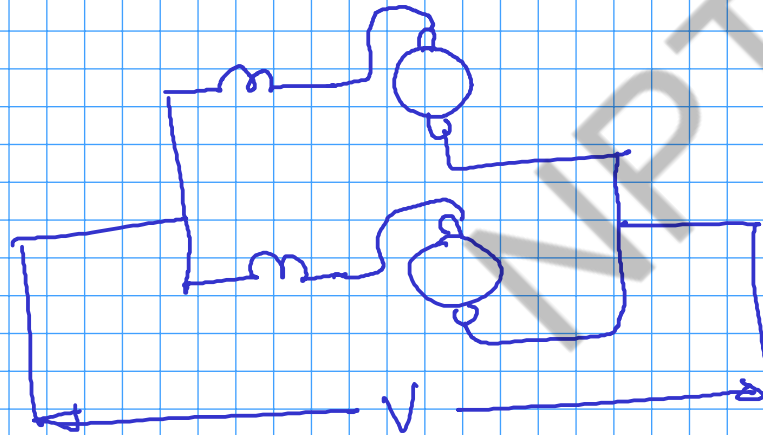
$$T_{e2} = T_{L2} = \bar{K} I^2 \dots \textcircled{3}$$

$$\left(\frac{I_2}{10} \right)^2 = \frac{T_{L2}}{T_{L1}} = 1 \quad \& \quad I_2 = 10A$$

$$150 = K I_2 n_2$$

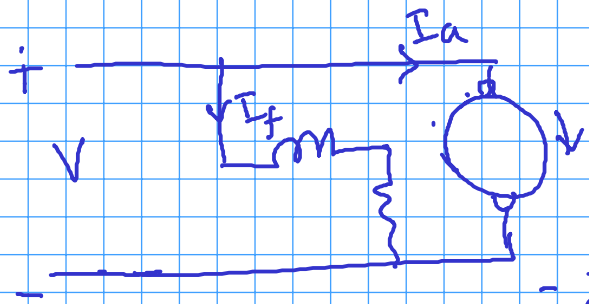
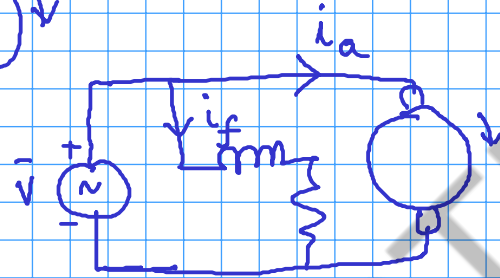
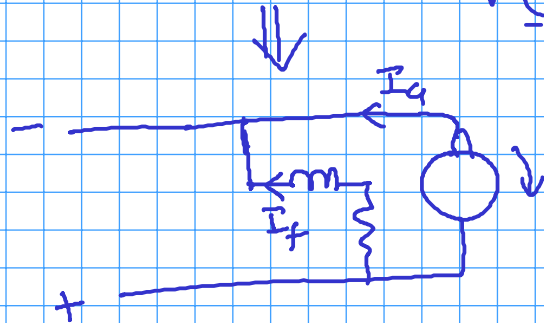
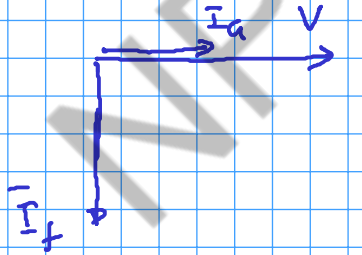
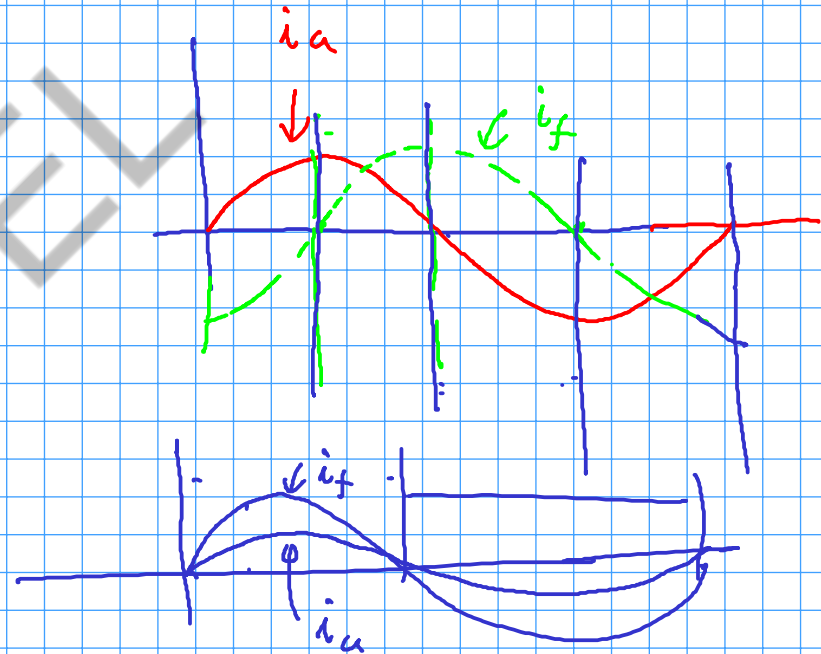


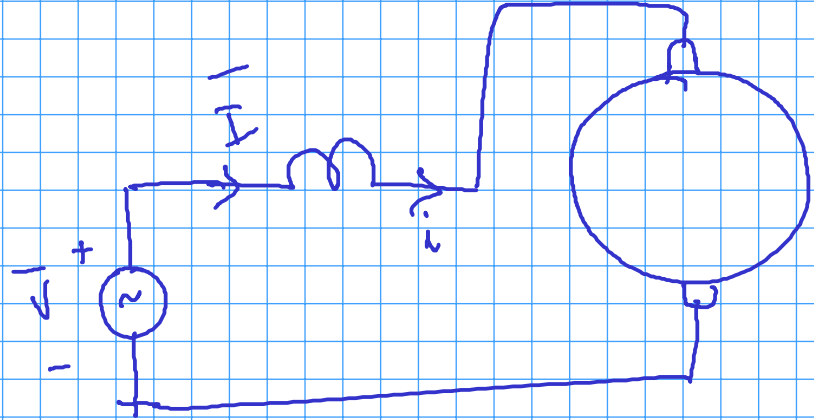
Dec-88



DC Shunt motor

$$T_e \propto I_f I_a$$



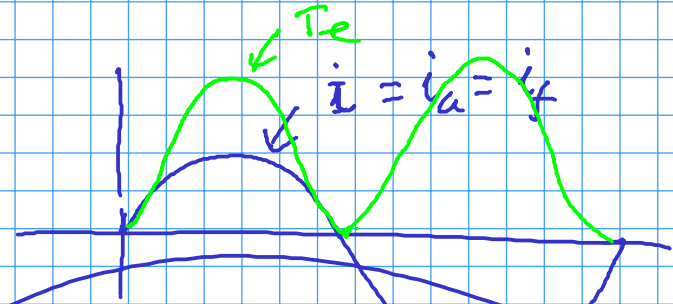
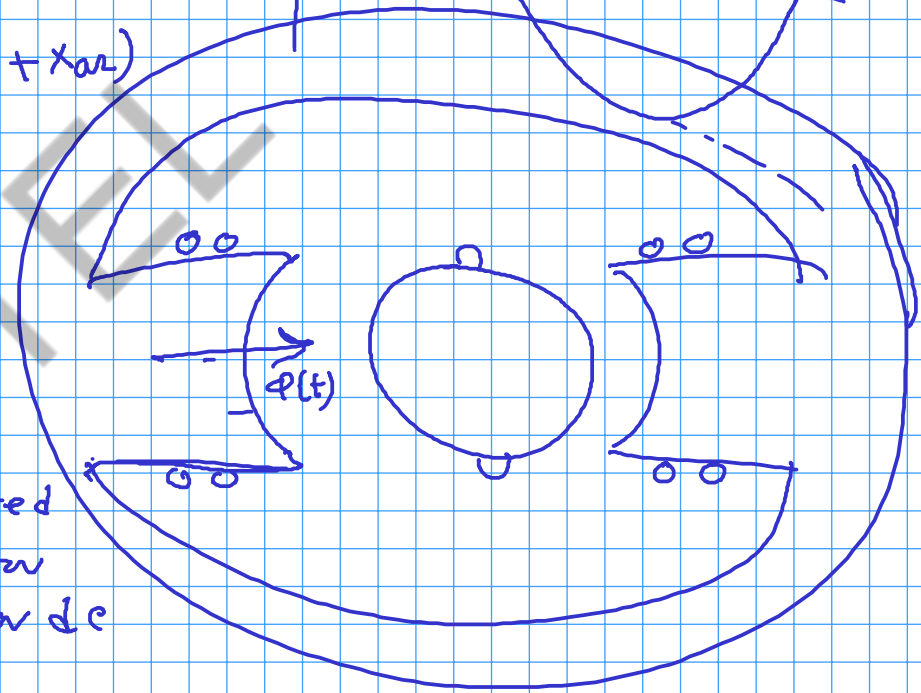


Universal motor

$$\bar{V} = \bar{I}(r_a + r_{se})$$

$$+ \bar{I} j (x_{se} + x_{ar})$$

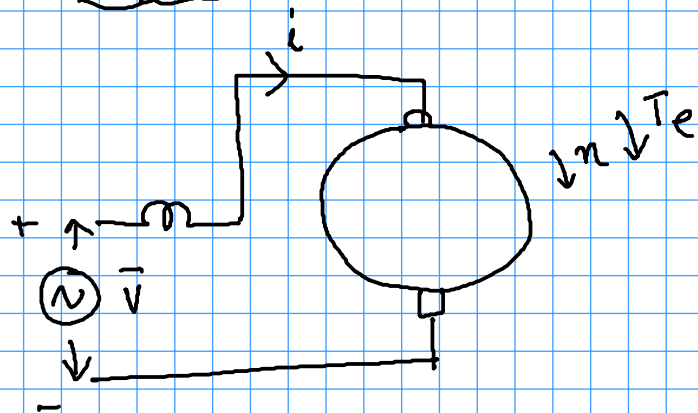
$$+ \bar{E}_b$$



• The stator must be laminated

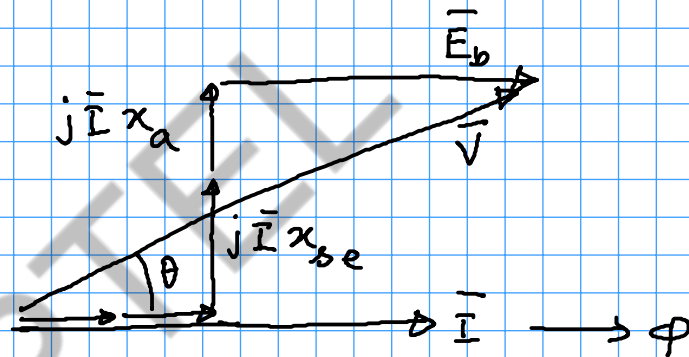
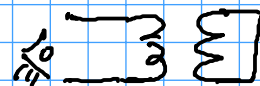
Armature is laminated no matter whether the motor is operated from ac or dc supply

Universal (series motor)
dc/ac

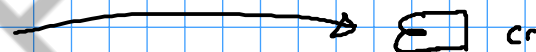
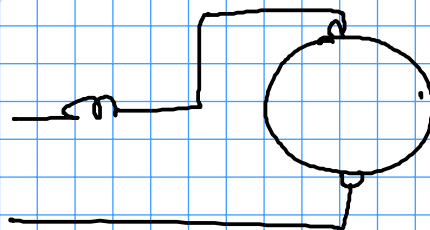


$$\bar{V} = \bar{I} (r_a + r_{se}) + j\bar{I} (x_{se} + x_a) + \bar{E}_b$$

$$e_b = k\phi\omega$$



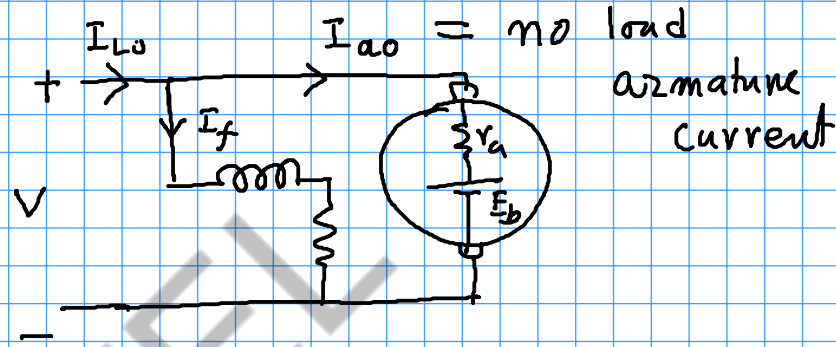
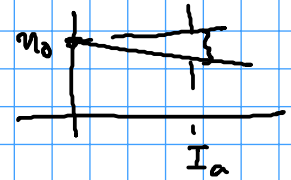
Compensating
to reduce $\bar{I}_a x_a$



Testing on D.C machines

① Swinburne Test

Run the motor under no load condition.



$$P_{\text{input}} = V I_{L0}$$

$$= V I_f + V I_{a0}$$

$$V I_f = \text{field cu loss}$$

$\therefore V I_{a0} = \text{Power input to armature.}$

$$\text{Cu loss in the armature} = I_{a0}^2 r_a$$

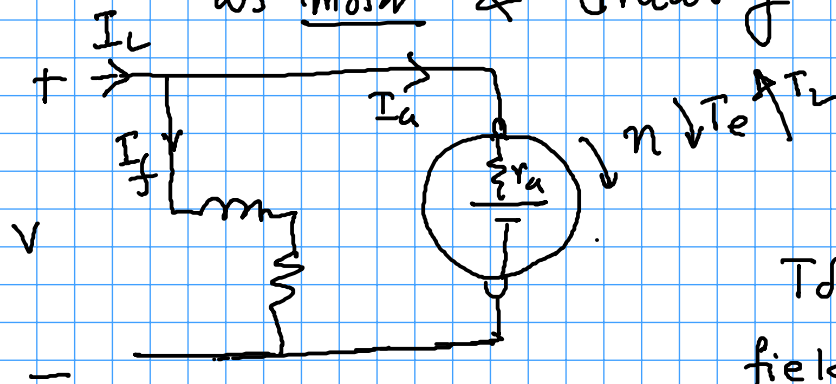
$$\therefore \text{Gross power developed by the armature} = V I_{a0} - I_{a0}^2 r_a$$

$$= (V - I_a r_a) I_a$$
$$= E_b I_a$$

$P_{\text{rot loss}}$

$$\therefore \text{Rotational loss} = \phi V I_{a0} - I_{a0}^2 r_a$$

Suppose the machine is operating as motor & drawing rated armature current I_a . (loaded motor)



Predict the η of the motor.

$P_{\text{rot-loss}}$ is known.

$$\text{Total input} = V I_L$$

$$\text{field Cu loss} = V I_f$$

$$\text{Arm. Cu loss} = I_a^2 r_a$$

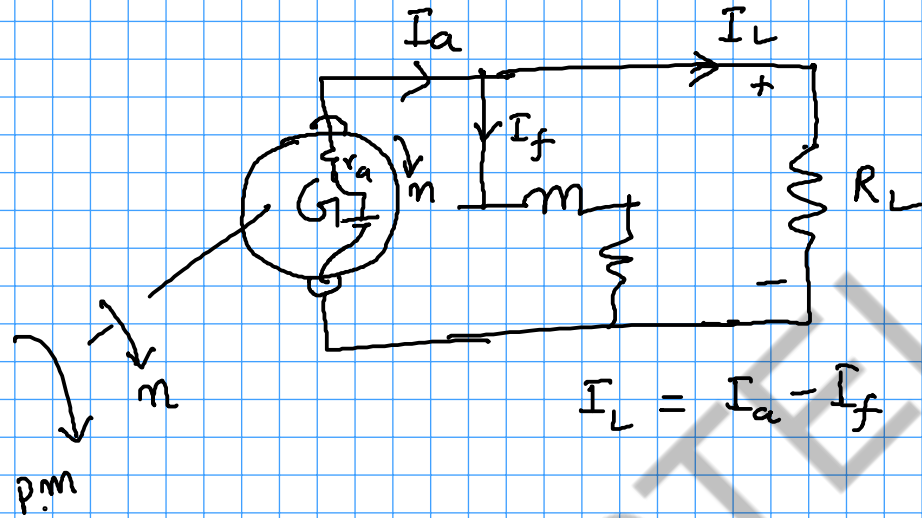
Gross Power converted to mech energy

$$= V I_L - V I_f - I_a^2 r_a$$

$$V I_a - I_a^2 r_a = E_b I_a$$

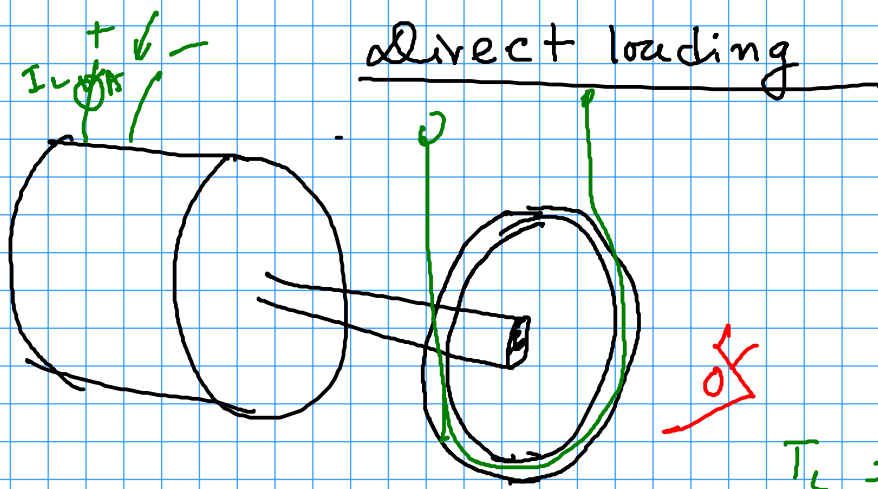
η output mech. power

$$\eta_m = \frac{(V I_a - I_a^2 r_a - P_{\text{rot-loss}})}{V I_L}$$



$$\eta_G = \frac{V I_L}{(V I_L + V I_f + I_a^2 r_a + P_{rot})}$$

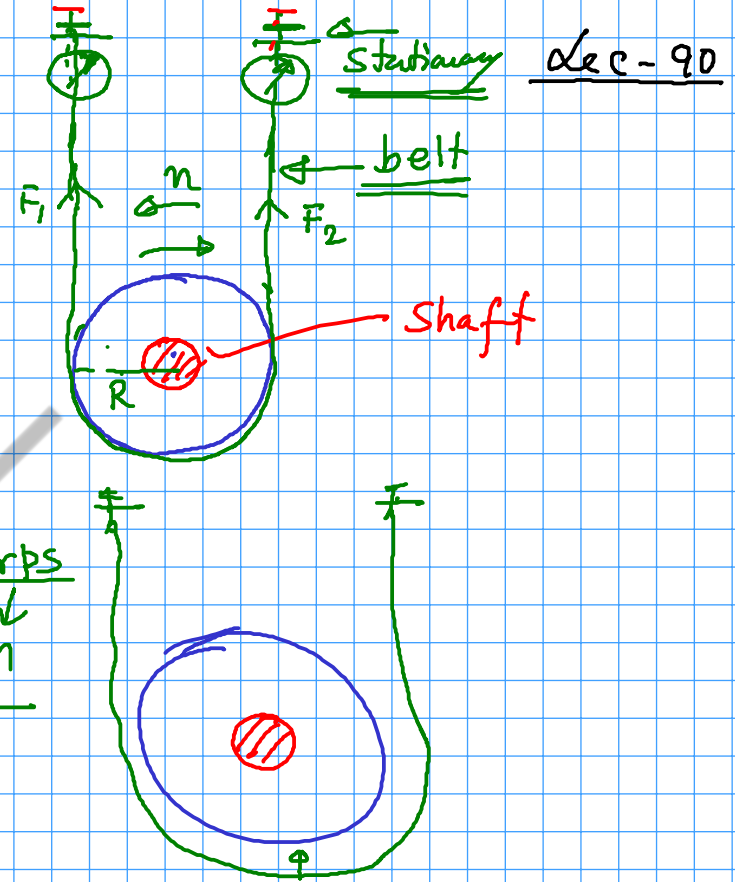
Input mechanical power from Prime mover



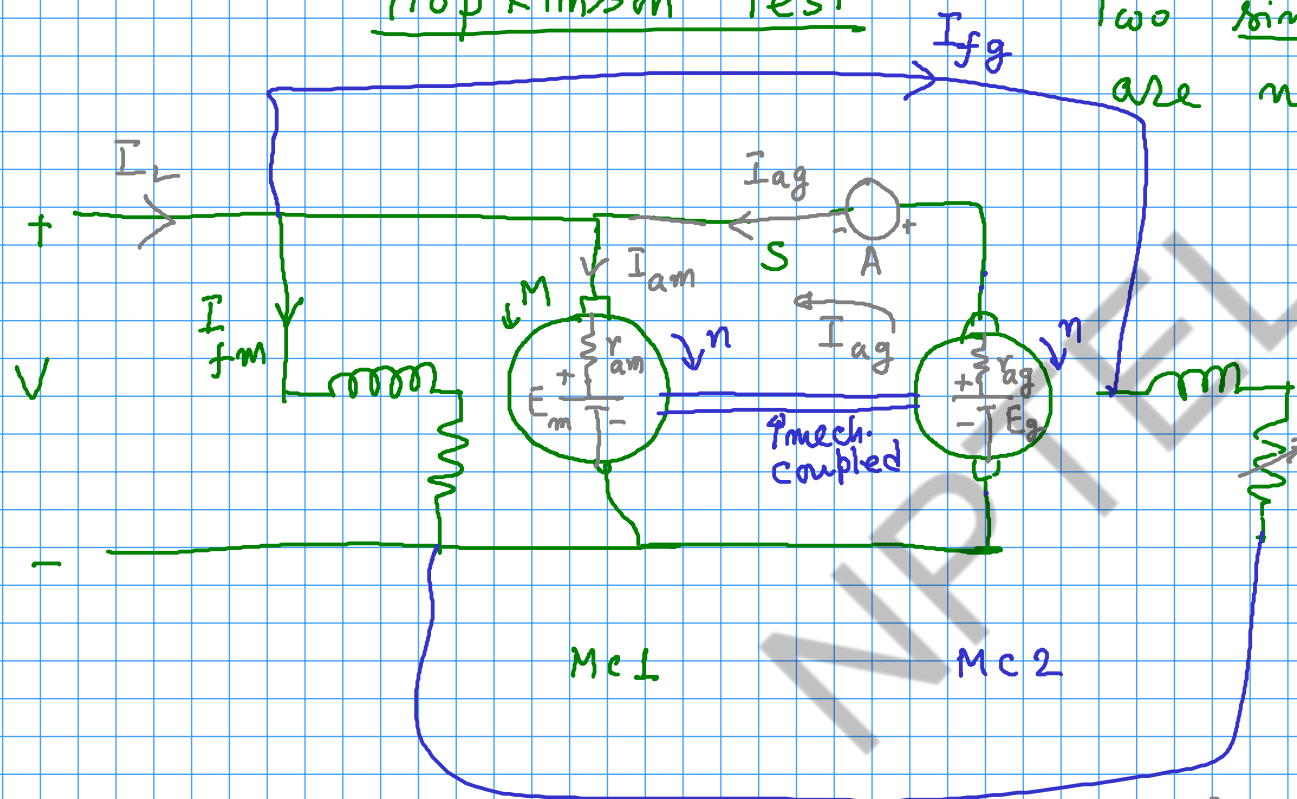
$$T_L = (F_1 - F_2) R$$

$$\eta = \frac{(F_1 - F_2) R \cdot 2\pi n}{V I_L}$$

rps
↓

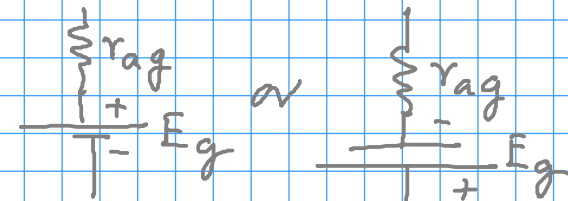


Hopkinson Test



Two similar D.C shunt m/cs are needed

of $E_g > E_m$



Reading of voltmeter

$$E_m - E_g$$

≈ 0

Then close S

$$V I_L - V I_{fm} - V I_{fg} - I_{am}^2 r_{am} - I_{ag}^2 r_{ag} = \text{Rotational loss of both the m/cs} = W_0$$

$\therefore$ Rotational loss of each machine = $W_0/2$