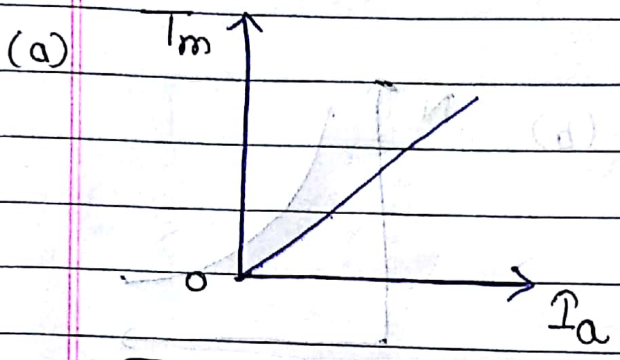
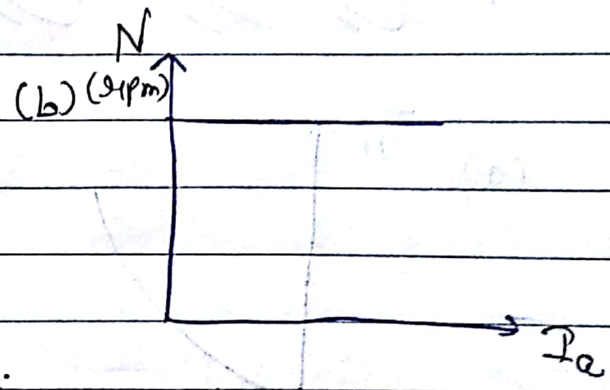
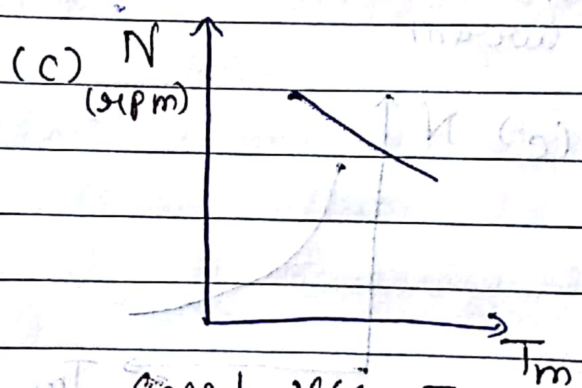
For a shunt-wound DC motor-



Torque V/S Armature current



Speed V/S Armature current



Speed V/S Torque

From (6) & (7)

$$\omega_m T_m = E_b I_a$$

$$\Rightarrow T_m = \frac{E_b I_a}{\omega_m} = \frac{E_b I_a}{2\pi N} \times 60$$

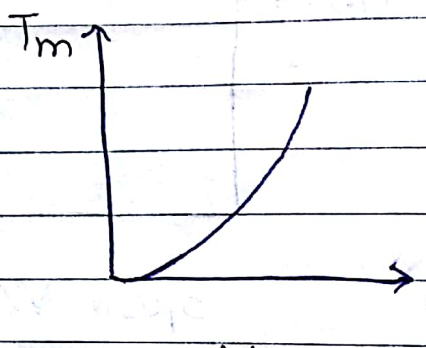
$$\& \quad E_b = \frac{\phi Z N P}{60 \times A}$$

Speed Regulation →

$$= \left(\frac{\text{No-load speed} - \text{Full-load speed}}{\text{Full-load speed}} \right) \times 100$$

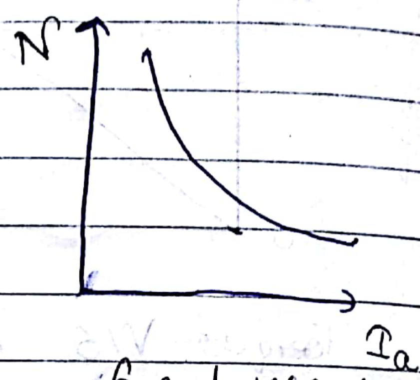
For a series- wound DC motor :-

(a)



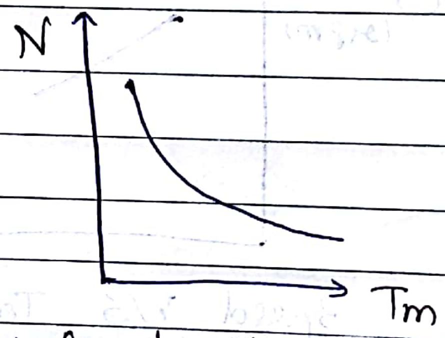
Torque V/S Armature current

(b)



Speed V/S ~~Arma~~ Armature Current

(c)



Motor Speed VS Torque

$$\phi \propto I_f \quad \Rightarrow \quad \phi \propto I_a$$

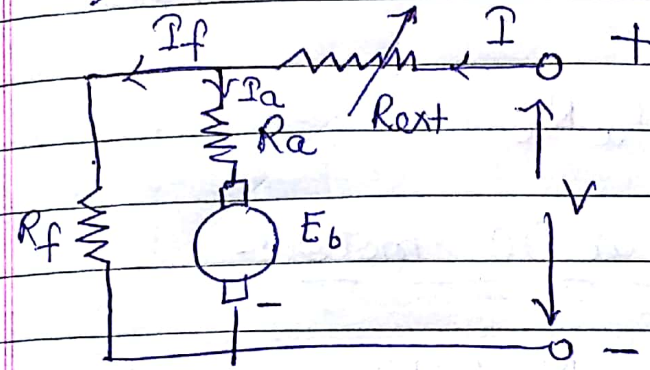
$$E_b = \frac{\phi Z N P}{60 A} \qquad [\Rightarrow E_b \propto I_a]$$

$$\omega_m T_m = E_b I_a$$

$$T_m \propto \frac{E_b I_a}{\omega_m}$$

$$\boxed{T_m \propto I_a^2}$$

The need for starter in a DC motor :-



When we apply an external Voltage 'V' to the motor, initially the motor speed $N = 0$.

Hence $E_b = \frac{\phi Z N P}{60 A} = 0$

Hence, the armature current $I_a = \frac{V - E_b}{R_a}$ is quite large (since the armature resistance R_a is generally small). This will damage the motor. We use "starter" to to avoid this problem. Starter is nothing but a variable resistant R_{ext} put in series with the motor. Initially, we make $R_{ext.}$ quite high. As motor starts picking speed, we generally reduce R_{ext} and make it almost zero by the time the motor has picked up the full-speed.

Speed Control →

$$\text{Speed } (N) \propto \frac{E_b}{\phi}$$

(i) By changing ϕ : (Field or flux control method)

$\phi \propto I_f$

$\Rightarrow \phi = K I_f$

[$K \rightarrow$ constant of prop.]

(ii) By Change E_b :
(Armature control method)

$$E_b = V - I_a R_a$$

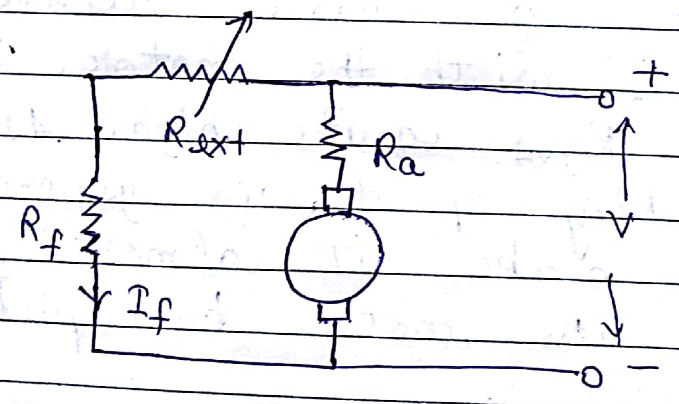
Speed Control of a DC motor:-

Since, $N \propto \frac{E_b}{\phi}$ — ①

We can change N by "Armature control" method or "Field (flux) Control" method.

(a) Shunt Wound motor =>

(i) Flux Control method:->



I_f changes with R_{ext}.

& Since $\phi \propto I_f$

$\therefore$ ϕ changes with R_{ext}.

Field Current (I_f) is given by -

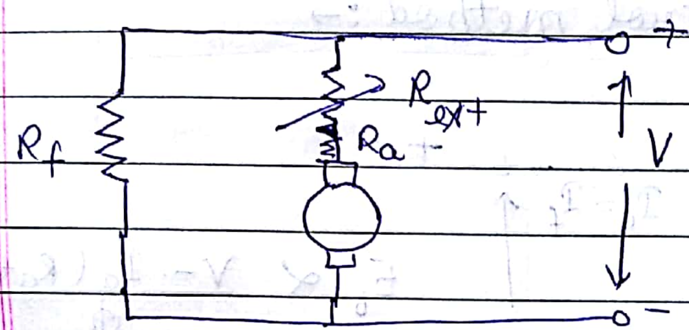
$$I_f = \frac{V}{R_f + R_{ext}} \quad — ①$$

Flux & Armature Control Methods → Principal methods

$$\phi = K I_f \quad \text{—} \; (2)$$

$$\because N \propto \frac{1}{\phi} \Rightarrow N \propto \frac{1}{I_f} \Rightarrow N \propto R_{ext.}$$

(ii) Armature Control method :→



$$\cancel{N \propto \frac{V - I_a R_a}{\phi} \quad \text{—} \; (1)}$$

$$N \propto \frac{V - I_a (R_a + R_{ext})}{\phi} \quad \text{—} \; (1)$$

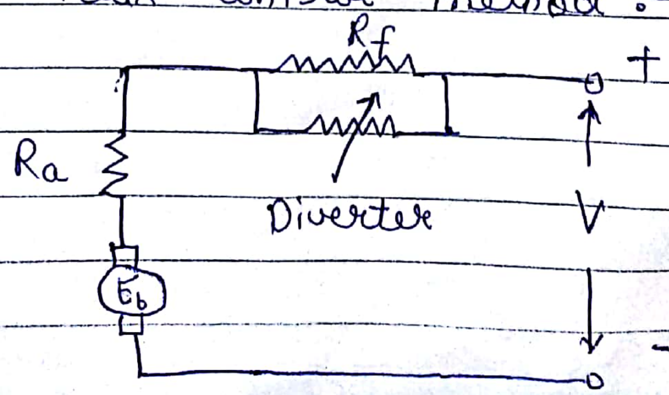
$\phi \rightarrow$ Constant

(iii) Voltage Control method :-

external Voltage is ~~cont~~ provided to Control I_f.

(b) Series - Wound DC motor ⇒

(i) Flux - Control method :→

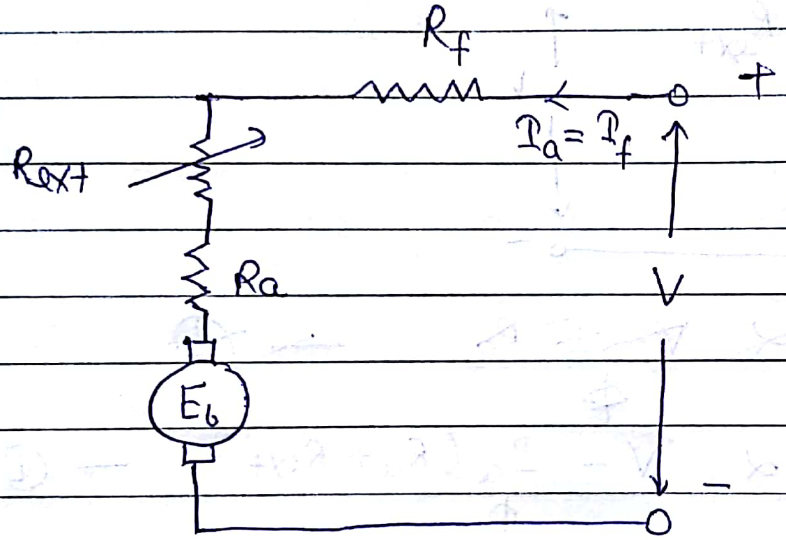


Diverter → R_{ext}

$$N \propto \frac{E_b}{\phi}$$

Diverter can ~~be~~ have varied resistance per "continuous control" or "tapped-control" ('Discrete values)

(ii) Armature Control method :→



$$E_b \propto \frac{V - I_a(R_a + R_{ext} + R_f)}{\phi}$$