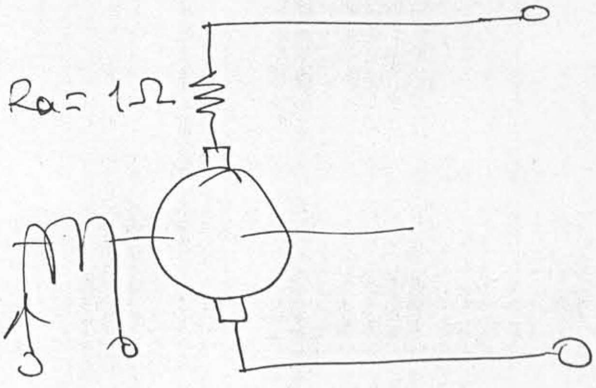
Ex1 Separately excited dc motor

$I_{a(rated)} = 100\,A$

$R_a = 1\,\Omega$



E_a vs I_f at 1000 RPM

$E_a = 200\, I_f \qquad I_f \leq 1.0\,A$

$E_a = 100\, I_f + 100 \qquad I_f > 1.0\,A$

a) Obtain its magnetization ch at 500 rpm

Since $E_a = K_a \phi_d \omega_r$

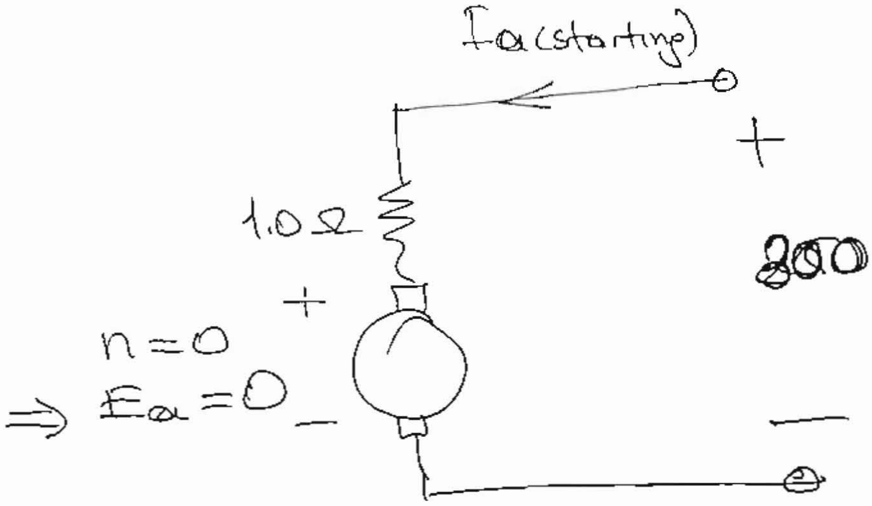
then $\left.\dfrac{E_{a_1}}{E_{a_2}}\right|_{\substack{I_f - cnst \\ \phi_d - cnst}} = \left.\dfrac{\omega_{r_1}}{\omega_{r_2}}\right|_{\substack{I_f - cnst \\ \phi_d - cnst}} = \left.\dfrac{n_1}{n_2}\right|_{\substack{I_f - c \\ \phi_d -}}$

$\Rightarrow E_{a_2} = \dfrac{n_2}{n_1} E_{a_1} = \dfrac{500}{1000} E_{a_1} = 0.5\, E_{a_1}$ //

New Ch: $E_a = 100\, I_f \qquad I_f \leq 1.0\,A$

$E_a = 50\, I_f + 50 \qquad I_f > 1.0\,A$ //

b) If it is started by direct on starting technique compute initial value of starting current by assuming that $V_{t(rated)} = 300$ V and $I_f = 1.0$ A.



$V_t = E_a + I_a R_a$ (for Motoring Operation)

$300 = 0 + I_a \times 1.0$

$\Rightarrow I_a = 300 \text{ A} \gg I_{a(rated)}$ //

Compute Ia when the speed reaches 500 RPM.

at 500 rpm E_a is 100 V.

$\therefore \quad 300 = 100 + I_a \times 1.0$

$I_a = \frac{300 - 100}{1.0} = 200$ A //

Compute Ia at 1000 rpm.

at 1000 rpm E_a is 200 V

$300 = 200 + I_a \times 1.0$

$\therefore \quad I_a = \frac{300 - 200}{1.0} = 100 \text{ A} = I_{a(rated)}$ //

c) Compute T_e at $n = 1000$ rpm and $I_f = 1.0$ A

at 1000 rpm and $I_f = 1.0$ A : $E_a = 200$ V

$$E_a = K_a \Phi_d \, \omega_r$$

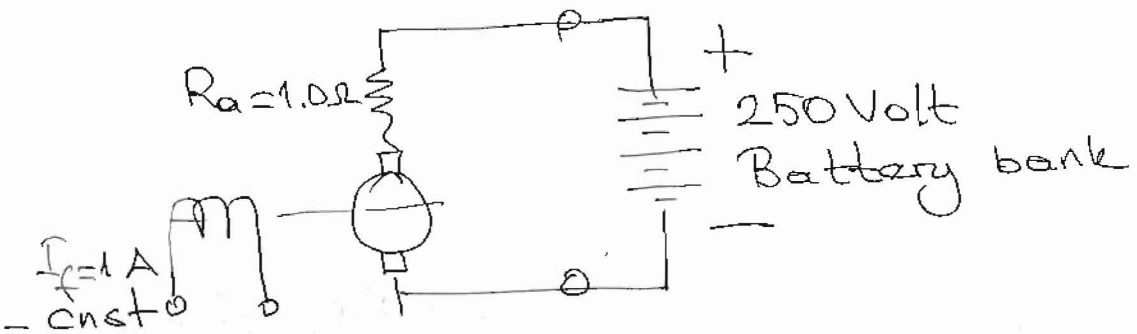
$$200 = K_a \Phi_d \times 1000 \, \frac{2\pi}{60}$$

$$\therefore \; K_a \Phi_d = 1.91$$

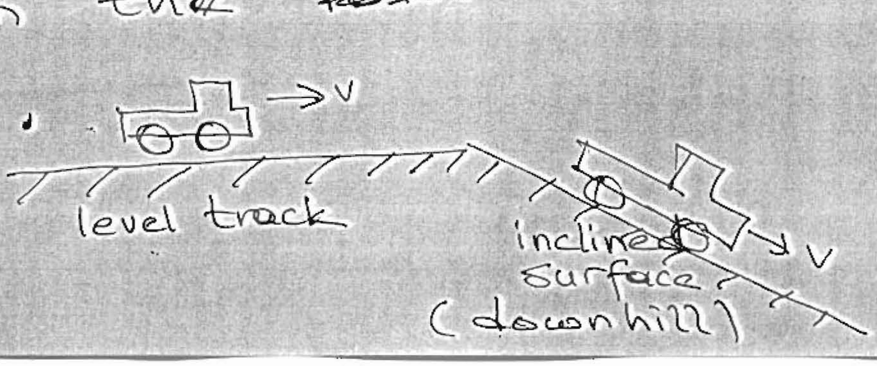
$$T_e = K_a \Phi_d \, I_a$$

$$T_e = 1.91 \times 100 = 191 \text{ Nm} \; //$$

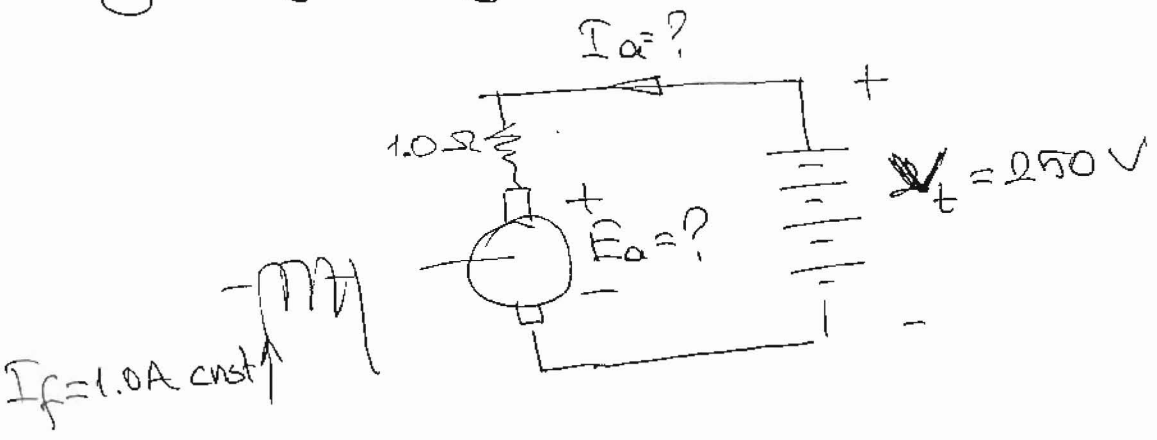
d) Let us drive an electric car by using the separately excited dc motor given above.



Consider the following track on the ~~rotor~~ road.



Compute the maximum speed of the motor on the level track by neglecting friction and windage losses. (4)



Since T_L owing to gravitational force on a level track is zero and $T_{f\&w} = 0$ then $T_e = T_L + T_{f\&w} = 0$ Nm

$$T_e = K_a \Phi_d I_a \Rightarrow I_a = 0 \text{ //}$$

$$V_t = E_a + I_a R_a$$

$$250 = E_a + 0$$

$$\therefore E_a = 250 \text{ V //}$$

at $I_f = 1.0$ A $\quad E_{a_2} = \dfrac{N_2}{1000\,\text{rpm}} \times 200$ Volts

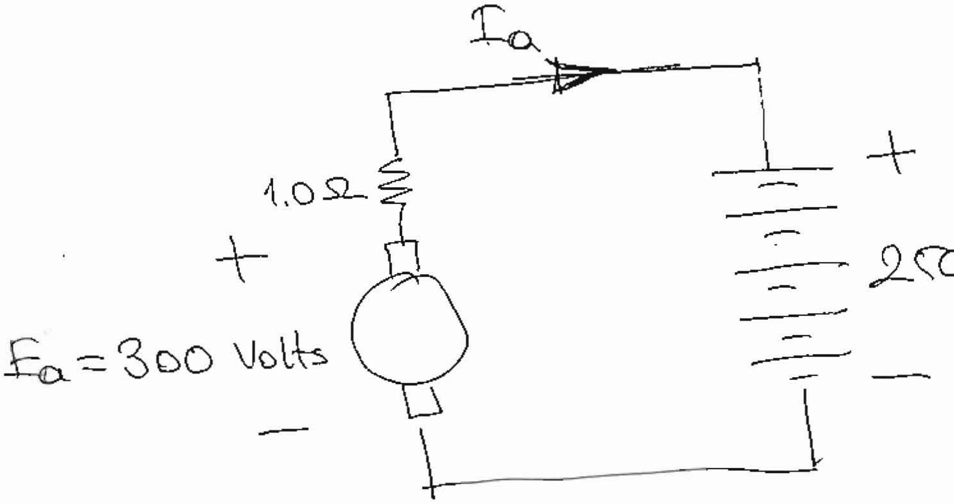
$$250 = N_2 \times 0.2$$

$$\Rightarrow N_2 = 1250 \text{ rpm //}$$ max motor speed

Assume now that the electric vehicle moves downhill at a constant speed (Constant motor speed is 1500 rpm). Identify the operation mode of the dc machine. Compute electromechanical torque and electromechanical power. ~~[illegible]~~.

At 1500 rpm and $I_f = 1.0$ A

$$E_a = \frac{1500}{1000} \times 200 = 300 \text{ Volts}$$



Armature current reverses ($E_a > V_t$)

$$I_a = \frac{V_t - E_a}{R_a} = \frac{250 - 300}{1.0} = -50 \text{ A}$$

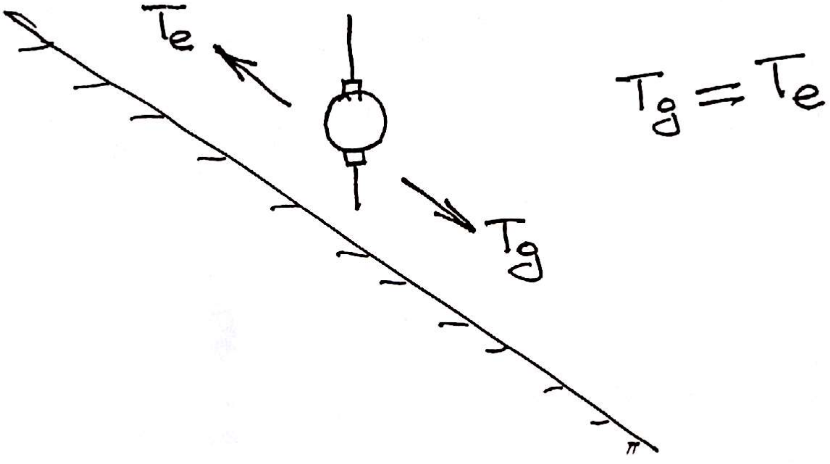
Electromechanical Power, $P_e = E_a I_a = -300 \times 50 = -15000$ W

(−) sign: Mechanical Power Converted to Electrical Form.

DC M/C operates in GENERATING Mode.

$$T_e = K_a \phi_d I_a$$

$$T_e = 1.91 \times (-50) = -95.5 \text{ Nm}$$



$T_g = T_e$

This technique is known as the ELECTRIC BRAKING. Since the electrical energy generated will then be stored in the battery bank, it is called REGENERATIVE BRAKING technique.

T_g owing to gravitational force tends to move the electric vehicle down hill.

What will happen if the driver increases I_f from 1.0 A to 1.5 A?

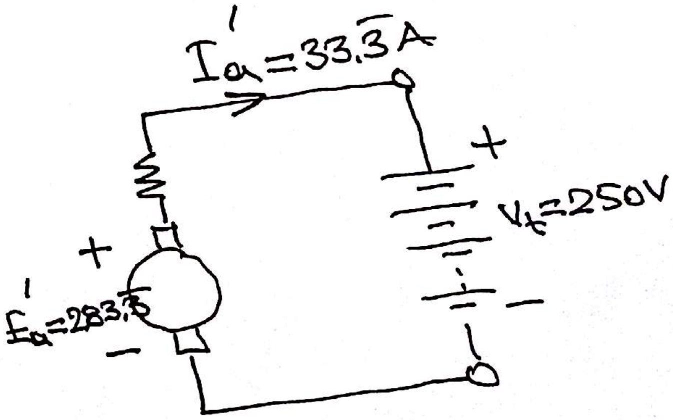
T_g and hence T_e remains the same.

$T_e = K_a \phi_d' I_a'$ $\quad$ ϕ_d is increased from 1.0 pu to 1.5 pu

Therefore,

$$\text{New } I_a' = \frac{I_a}{1.5} = \frac{50}{1.5} = 33.\overline{3}\text{ A}$$

$$\text{New } E_a' = V_t + R_a I_a = 250 + 1.0 \times 33.\overline{3} = 283.\overline{3}\text{ V}$$



If the shaft speed were 1000 rpm then E_a would be $E_a = 100 I_f + 100$

$= 100 \times 1.5 + 100$

$= 250$ volts

However, E_a is $283.\bar{3}$ V

Therefore, $\left.\dfrac{n_2}{n_2} = \dfrac{E_{a1}}{E_{a2}}\right|_{I_f = 1.5A}$

New $n = 1133$ rpm //

If one increases I_f and hence ϕ_d, electric vehicle starts to move downhill at a lower speed.

Repeat the problem by assuming that I_f is reduced from 1.0 A to 0.5 A.