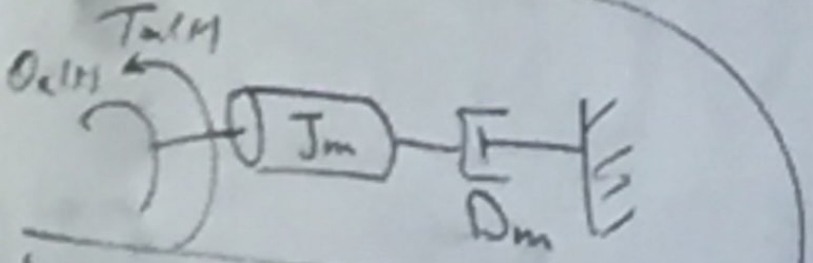
$$(R_a + sL_a) I_a(s) + V_b(s) = E_a(s)$$

$$(R_a + sL_a) \frac{T_m(s)}{k_t R} + K_b s \Theta_m(s) = E_a(s)$$



$$(J_m s^2 + D_m s)\, \Theta_m(s) = T_m(s)$$

$$(R_a + sL_a)\left(\frac{J_m s^2 + D_m s}{k_t}\right)$$

$\rightarrow R_a \gg L_a$

$$\left(\frac{R_a}{k_t}\left(J_m s^2 + D_m s\right)\right.$$

$$\frac{\Theta_m(s)}{E_a(s)} = \frac{k_t/R_a}{J_m s^2 + D_m}$$

$$= \frac{k_t/R_a}{s\left(s\right.}$$

$$(R_a + sL_a)\left(\frac{J_m s^2 + D_m s}{k_t}\right)\Theta_m(s) + k_b s\,\Theta_m(s) = E_a(s)$$

$\Theta_a(s)$

$E_a(s)$

$\Rightarrow R_a \gg L_a$

$$\left(\frac{R_a}{k_t}\left(J_m s^2 + D_m s\right) + k_b s\right)\Theta_m(s) = E_a(s)$$

$$\frac{\Theta_m(s)}{E_a(s)} = \frac{k_t/R_a}{J_m s^2 + D_m s + \frac{k_b k_t}{R_a} s}$$

$$= \frac{k_t/R_a J_m}{s\left(s + \frac{D_m}{J_m} + \frac{k_b k_t}{J_m R_a}\right)}$$

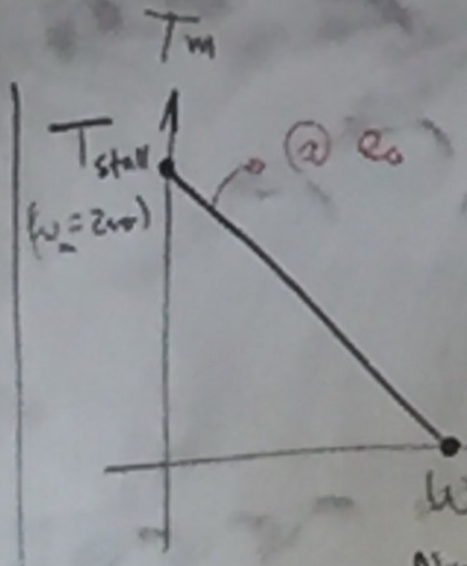
$$\frac{\Theta_m(s)}{E_a(s)} = \frac{\frac{K_t}{R_a J_m}}{s\left(s + \frac{1}{J_m}\left(D_m + \frac{K_t K_b}{R_a}\right)\right)} = \frac{K}{s(s+\alpha)}$$

$$\left(\frac{R_a}{K_t}\right) T_m(t) + K_b s\,\Theta_m(s) = E_a(s)$$

$$\frac{R_a}{K_t} T_m(t) + K_b \underbrace{\frac{d}{dt}\theta_m(t)}_{\omega_m(t)} = e_a$$

$$\frac{R_a}{K_t} T_m + K_b \omega_m = e_a$$

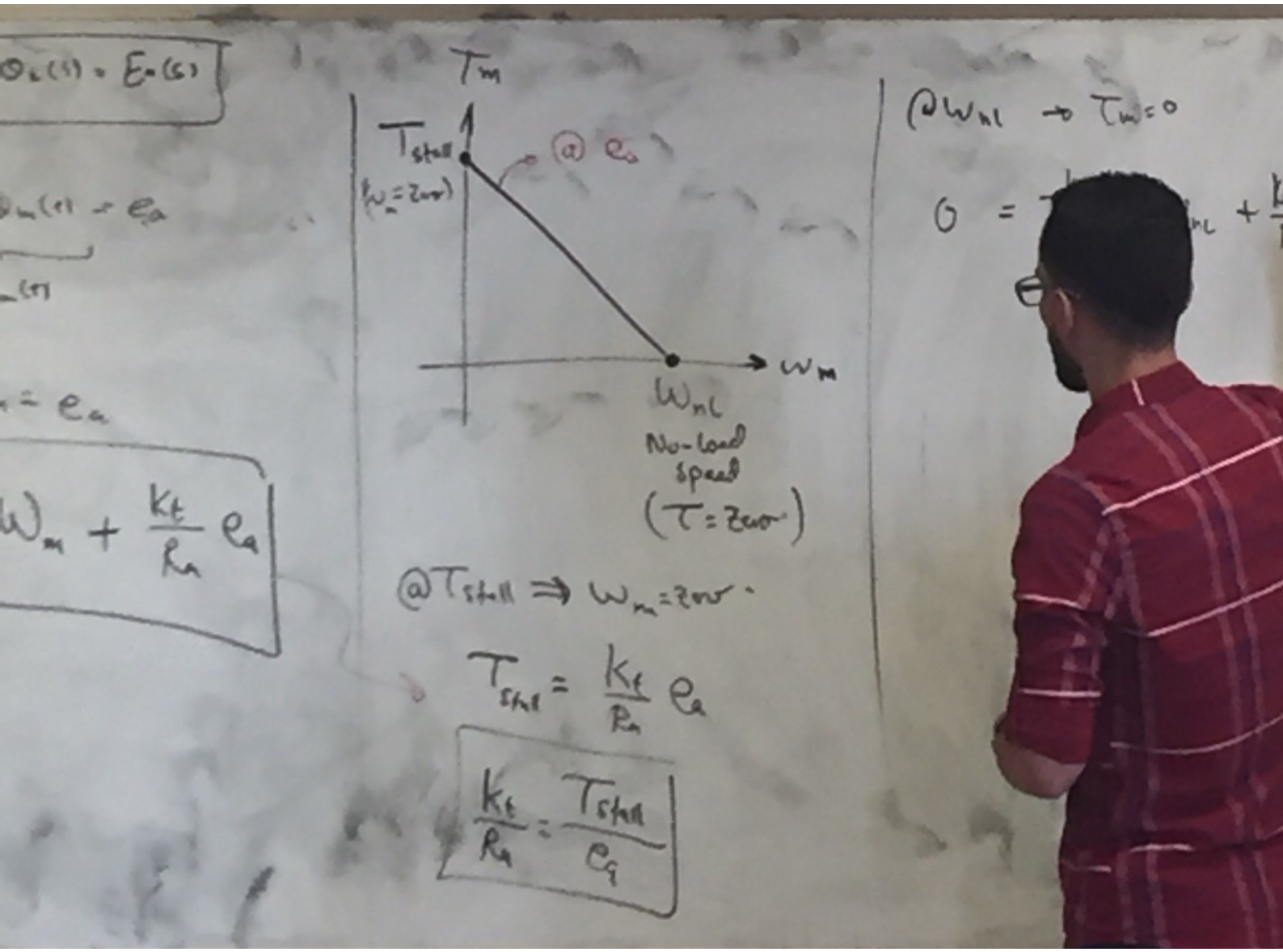
$$T_m = -\frac{K_b K_t}{R_a}\omega_m + \frac{K_t}{R_a} e_a$$



@ $T_{stall} \Rightarrow \omega_m =$

$$T_{stall} = \frac{K_t}{R_a}$$

$$\frac{K_t}{R_a} = \frac{T_{stall}}{e_a}$$



ω_{nl}
No-load
Speed
($T = zero$)

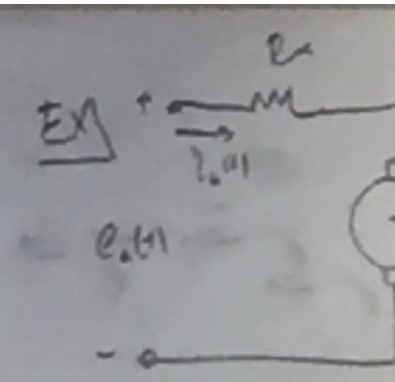
ω_m

ω_{nl} → $T_m = 0$

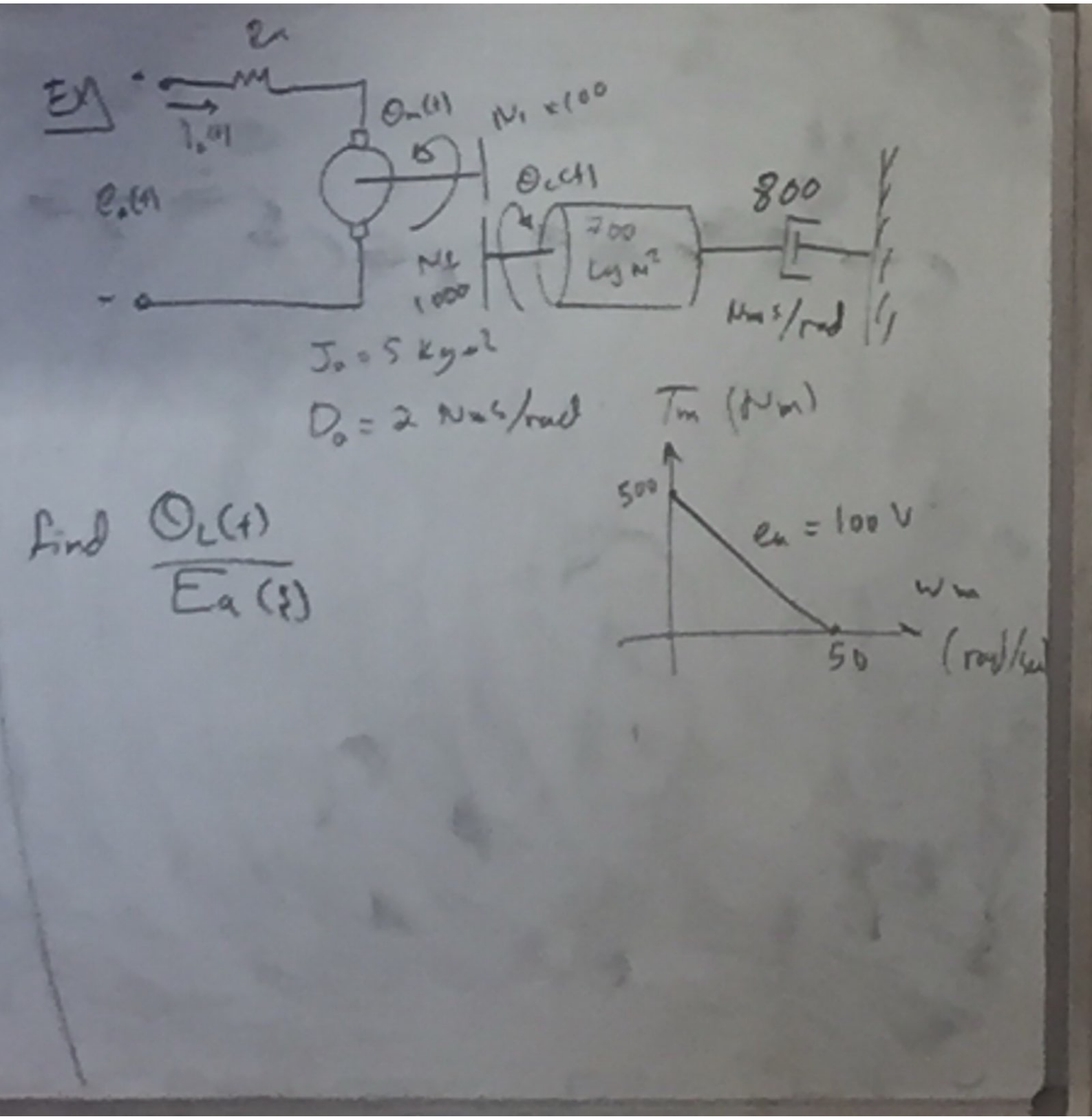
$$0 = -\frac{k_b K_b}{R_a}\omega_{nl} + \frac{K_t}{R_a} e_a$$

$k_b \omega_{nl} = e_a$

$$\boxed{k_b = \frac{e_a}{\omega_{nl}}}$$



find $\frac{\Theta_L(s)}{E_a(s)}$



Find $\frac{\Theta_L(s)}{E_a(s)}$

① $\frac{K_t}{R_a} = \frac{T_{stall}}{e_a} = \frac{500}{100} = 5$

② $K_b = \frac{e_a}{\omega_L} = \frac{100}{50} \times 2$

③ $J_m = J_a + J_L \left(\frac{N_1}{N_2}\right)^2$

$= 5 + 700\left(\frac{100}{1000}\right)^2 = 12$

④ $D_m = D_a + D_L \left(\frac{N_1}{N_2}\right)^2$

$= 2 + 800\left(\frac{100}{1000}\right)^2 = 10$

$\frac{\Theta_m(s)}{E_a(s)} = \frac{K_t}{R_a J_m}$

$s\left[s + \frac{1}{J_m}\left(D_m + \frac{K_t K_b}{R_a}\right)\right] = \frac{0.417}{s(s + 1.66(2)}$

$\frac{\Theta_m}{\Theta_L} = \frac{N_2}{N_1} =$

$\Theta_m = 10\,\Theta_L$

$\frac{10\,\Theta_L(s)}{E_a(s)} =$

$\frac{\Theta_L(s)}{E_a(s)} =$

$$\frac{\theta_m}{\theta_L} = \frac{N_2}{N_1} = \frac{1000}{100} = 10$$

$$\boxed{\theta_m = 10\,\theta_L}$$

$$\frac{10\,\theta_L(s)}{E_a(s)} = \frac{0.417}{s(s+1.667)}$$

$$\boxed{\frac{\theta_L(s)}{E_a(s)} = \frac{0.0417}{s(s+1.667)}}$$

$$@\,\omega_{nl} \rightarrow T_m = 0$$

$$0 = -\frac{k_b K_t}{R_a}\omega_{nl} + \frac{K_t}{R_a}$$

$$k_b\,\omega_{nl} = e_a$$

$$\boxed{k_b = \frac{e_a}{\omega_{nl}}}$$

$$= \frac{0.417}{s(s+1.667)}$$