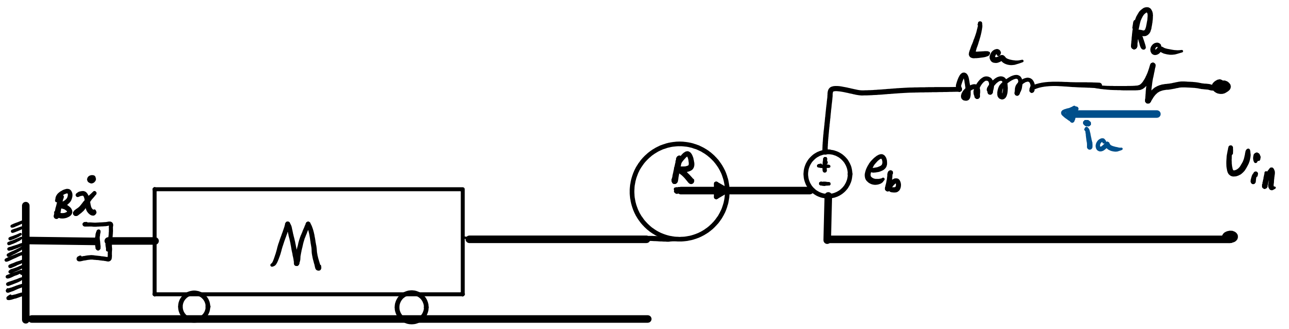
Mathematical model of the system



Givens:

$R = 1.1\ cm = 0.011\ m$

$L_a = 0.01\ H$

$V_{in} = 12\ V$

$R_a = \frac{V_{in}}{I_{stall}} = \frac{12}{1.5} = 8\ \Omega$

$M = 107\ gm = 0.107\ Kg$

$J_r = 0.0002\ Kg.m^2$

$K_t = 0.494\ N.m/A$

$b = 5 \times 10^{-6}\ \frac{N.m}{r/s}$

$Friction = 7.92\ N$

For electrical system:

$(R_a + \cancel{L_a \times S}) I(s) + e_b(s) = V_{in}(s)$

neglect

$e_b(s) = K_b \times S \times \theta_m(s)$

$T_m = K_t I(s)$

$\frac{R_a}{K_t} \times T_m(s) + K_b S \theta_m(s) = V_{in}(s)$

$$\boxed{16.19\ T_m(s) + 0.494 \times S \times \theta_m(s) = V_{in}(s)} \rightarrow (1)$$

For mechanical system:

$$J_{eq}\ddot{\theta}_2 = T_{meq} - b_{eq}\dot{\theta}_2$$

$$0.0002\,\ddot{\theta}_2 = T_m - 5\times10^{-6}\dot{\theta}_2$$

$$\boxed{T_m = 2\times10^{-4}\ddot{\theta}_2 + 5\times10^{-6}\dot{\theta}_2} \rightarrow (2)$$

Sub 2 in 1

$$V_{in}(s) = 3.24\times10^{-3}\ddot{\theta}_2 + 8.1\times10^{-5}\dot{\theta}_2 + 0.494\times\dot{\theta}_m$$

$\rightsquigarrow$ Assume $\frac{N_1}{N_2} = 1$, $\theta_1 = \theta_2$

$$V_{in}(s) = 3.24\times10^{-3}\ddot{\theta}_m + 0.494\,\dot{\theta}_m$$

$$V_{in}(s) = [3.24\times10^{-3}s^2 + 0.494\,s]\,\theta_m(s)$$

$$\boxed{\frac{\theta_m(s)}{V_{in}(s)} = \frac{1}{3.24\times10^{-3}s^2 + 0.494\,s}}$$

$$\boxed{\frac{\omega(s)}{V_{in}(s)} = \frac{1}{3.24\times10^{-3}s + 0.494}}$$