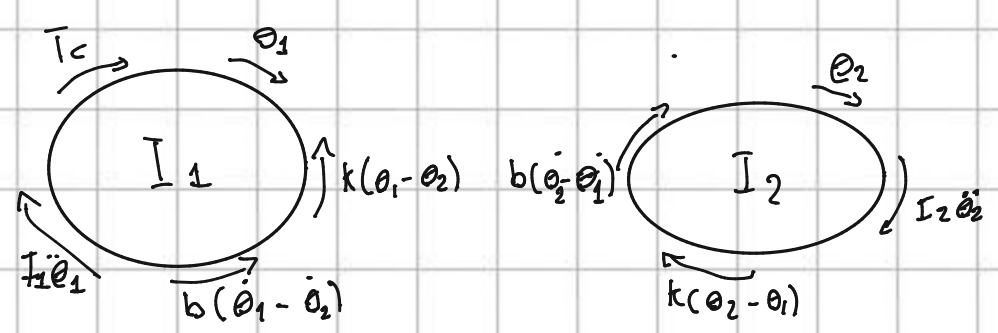
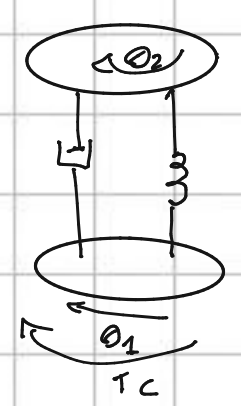


$\theta_2 = \text{Sensor}$
 $\theta_1 = \text{body}$



$I_1 \ddot{\theta}_1 + b(\dot{\theta}_1 - \dot{\theta}_2) + k(\theta_1 - \theta_2) = T_c$

$T_c \ddot{\theta}_1 = T_c - b(\dot{\theta}_1 - \dot{\theta}_2) - k(\theta_1 - \theta_2)$

$\ddot{\theta}_1 = \frac{T_c}{I_1} - \frac{k}{I_1} \theta_1 + \frac{k}{I_1} \theta_2 - \frac{b}{I_1} \dot{\theta}_1 + \frac{b}{I_1} \dot{\theta}_2$

$I_2 \ddot{\theta}_2 + b(\dot{\theta}_2 - \dot{\theta}_1) + k(\theta_2 - \theta_1) = 0$

$\ddot{\theta}_2 = -\frac{k}{I_2} \theta_2 + \frac{k}{I_2} \theta_1 - \frac{b}{I_2} \dot{\theta}_2 + \frac{b}{I_2} \dot{\theta}_1$

$q_1 = \theta_1 \quad q_3 = \theta_2$
 $\dot{q}_2 = \dot{q}_1 = \dot{\theta}_1 \quad \dot{q}_4 = \dot{q}_3 = \dot{\theta}_2$
 $\ddot{q}_2 = \ddot{\theta}_1 \quad \ddot{q}_4 = \ddot{\theta}_2$

$\dot{q}_2 = \frac{T_c}{I_1} - \frac{k}{I_1} q_1 + \frac{k}{I_1} q_3 - \frac{b}{I_1} \dot{q}_2 + \frac{b}{I_1} \dot{q}_4$

$\dot{q}_4 = -\frac{k}{I_2} q_2 + \frac{k}{I_2} q_1 - \frac{b}{I_2} \dot{q}_4 + \frac{b}{I_2} \dot{q}_2$

$$\begin{bmatrix} \dot{q}_1 \\ \dot{q}_2 \\ \dot{q}_3 \\ \dot{q}_4 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ \frac{k}{I_1} & -\frac{b}{I_1} & \frac{k}{I_1} & \frac{b}{I_1} \\ 0 & 0 & 0 & 1 \\ \frac{k}{I_2} & \frac{b}{I_2} & -\frac{k}{I_2} & -\frac{b}{I_2} \end{bmatrix} \begin{bmatrix} q_1 \\ q_2 \\ q_3 \\ q_4 \end{bmatrix} + \begin{bmatrix} 0 \\ \frac{1}{I_1} \\ 0 \\ 0 \end{bmatrix} T_c$$

$$\begin{bmatrix} \theta_1 \\ \theta_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} q_1 \\ q_2 \\ q_3 \\ q_4 \end{bmatrix} + \theta u$$