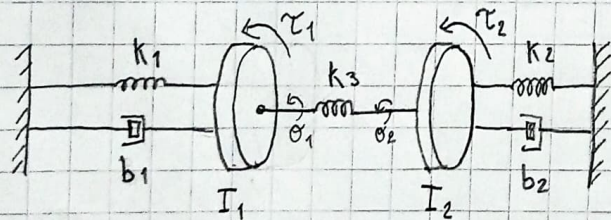
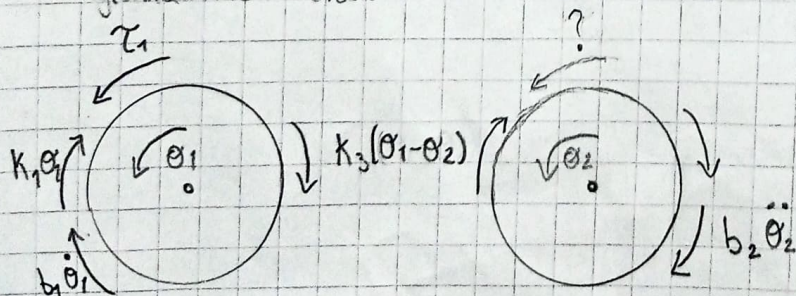


Ej.



• Diagrama de Fuerzas:



$$\rightarrow I_1 \ddot{\theta}_1 + b_1 \dot{\theta}_1 + k_1 \theta_1 + k_3 (\theta_1 - \theta_2) = \tau_1 = I_1 \ddot{\theta}_1 + b_1 \dot{\theta}_1 + \theta_1 (k_1 + k_3) - k_3 \theta_2$$

$$\rightarrow I_2 \ddot{\theta}_2 + b_2 \dot{\theta}_2 + k_2 \theta_2 + k_3 (\theta_1 - \theta_2) = 0 = I_2 \ddot{\theta}_2 + b_2 \dot{\theta}_2 + \theta_2 (k_1 + k_3) - k_3 \theta_1$$

→ Variables de estado:

$$q_1 = \theta_1 ; \quad \dot{q}_2 = \dot{q}_1 = \dot{\theta}_1 ; \quad \ddot{q}_2 = \ddot{\theta}_1$$

$$q_3 = \theta_2 ; \quad \dot{q}_4 = \dot{q}_3 = \dot{\theta}_2 ; \quad \ddot{q}_4 = \ddot{\theta}_2$$

$$\therefore \tau_1 = I_1 \ddot{q}_2 + b_1 \dot{q}_2 + q_1(k_1 + k_3) - k_3 q_3$$

$$\rightarrow \ddot{q}_2 = -\frac{k_1 + k_3}{I_1} q_1 - \frac{b_1}{I_1} \dot{q}_2 + \frac{k_3}{I_1} q_3 + \frac{1}{I_1} \tau_1$$

$$\therefore 0 = I_2 \ddot{q}_4 + b_2 \dot{q}_4 + q_3(k_1 + k_3) - k_3 q_1$$

$$\rightarrow \ddot{q}_4 = \frac{k_3}{I_2} q_1 - \frac{k_1 + k_3}{I_2} q_3 - \frac{b_2}{I_2} \dot{q}_4$$

$$\begin{bmatrix} \ddot{q}_1 \\ \ddot{q}_2 \\ \ddot{q}_3 \\ \ddot{q}_4 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ -\frac{k_1 + k_3}{I_1} & -\frac{b_1}{I_1} & \frac{k_3}{I_1} & 0 \\ 0 & 0 & 0 & 1 \\ \frac{k_3}{I_2} & 0 & -\frac{k_1 + k_3}{I_2} & -\frac{b_2}{I_2} \end{bmatrix} \begin{bmatrix} q_1 \\ q_2 \\ q_3 \\ q_4 \end{bmatrix} + \begin{bmatrix} 0 \\ \frac{1}{I_1} \tau_1 \\ 0 \\ 0 \end{bmatrix}$$

$$\begin{bmatrix} 0_1 \\ 0_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} q_1 \\ q_2 \\ q_3 \\ q_4 \end{bmatrix}$$