



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

$$T = I_1 \ddot{\theta}_1 + b_1 \dot{\theta}_1 + (k_1 + k_3) \theta_1 - k_3 \theta_2 \quad (1)$$

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

$$I_2 \ddot{\theta}_2 + b_2 \dot{\theta}_2 - k_3 \theta_1 + (k_2 + k_3) \theta_2 = 0 \quad (2)$$

$$q_1 = \theta_1$$

$$\dot{q}_2 = \dot{q}_1 = \dot{\theta}_1$$

$$\ddot{q}_3 = \ddot{q}_2 = \ddot{\theta}_1$$

$$y_1 = \theta_2$$

$$\dot{y}_2 = \dot{y}_1 = \dot{\theta}_2$$

$$\ddot{y}_3 = \ddot{y}_2 = \ddot{\theta}_2$$

$$\ddot{q}_3 = \frac{T}{I_1} - \frac{b_1}{I_1} \dot{q}_2 - \frac{k_1 + k_3}{I_1} q_1 + \frac{k_3}{I_1} y_1$$

$$\ddot{y}_3 = -\frac{b_2}{I_2} \dot{y}_2 - \frac{k_2 + k_3}{I_2} y_1 + \frac{k_3}{I_2} q_1$$

$$\begin{bmatrix} \ddot{q}_1 \\ \ddot{q}_2 \\ \ddot{y}_1 \\ \ddot{y}_2 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ -\frac{k_1 + k_3}{I_1} & \frac{k_3}{I_1} & -\frac{b_1}{I_1} & 0 \\ \frac{k_3}{I_2} & -\frac{k_2 + k_3}{I_2} & 0 & -\frac{b_2}{I_2} \end{bmatrix} \begin{bmatrix} q_1 \\ q_2 \\ y_1 \\ y_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ \frac{1}{I_1} \\ 0 \end{bmatrix} T$$

$$\begin{bmatrix} \theta_1 \\ \theta_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} q_1 \\ q_2 \\ y_1 \\ y_2 \end{bmatrix}$$