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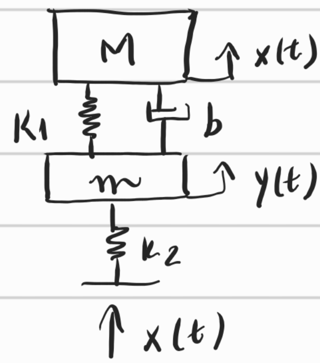
(2)




$$\begin{cases} M\ddot{x} + K_1(x-y) + b(\dot{x}-\dot{y}) = 0 \\ m\ddot{y} - K_1(x-y) - b(\dot{x}-\dot{y}) + K_2(y-z) \end{cases}$$

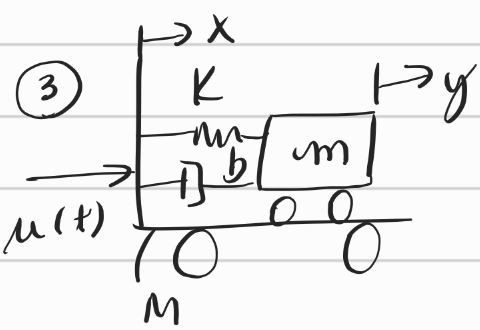
$$\begin{bmatrix} \dot{x} \\ \dot{y} \\ \ddot{x} \\ \ddot{y} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ -K_1/M & K_1/M & -b/M & b/M \\ K_1/m & (K_2-K_1)/m & b/m & -b/m \end{bmatrix} \begin{bmatrix} x \\ y \\ \dot{x} \\ \dot{y} \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 0 \\ K_2 \end{bmatrix} z(t)$$

$$\dot{x} = A \cdot x + B \cdot u$$

$$\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} x \\ y \\ \dot{x} \\ \dot{y} \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} z(t)$$

$$y = C \cdot x + D \cdot u$$

(3)




$$\begin{cases} M\ddot{x} - b(\dot{y}-\dot{x}) - k(y-x) = u \\ m\ddot{y} + b(\dot{y}-\dot{x}) + k(y-x) = 0 \end{cases}$$

$$\begin{bmatrix} \dot{x} \\ \dot{y} \\ \ddot{x} \\ \ddot{y} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ -k/M & k/M & -b/M & b/M \\ k/m & k/m & b/m & -b/m \end{bmatrix} \begin{bmatrix} x \\ y \\ \dot{x} \\ \dot{y} \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1/M \\ 0 \end{bmatrix} \cdot u$$

$$\dot{x} = A \cdot x + B \cdot u$$

④ $\dot{x} = [\dot{x}_G \ \ \dot{\theta} \ \ \dot{x}_1 \ \ \dot{x}_2 \ \ \ddot{x}_G \ \ \ddot{\theta} \ \ \ddot{x}_1 \ \ \ddot{x}_2]$

$$A = \begin{bmatrix} 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ -\frac{(k_1+k_2)}{M} & -\frac{(k_1-k_2)l}{2M} & \frac{k_1}{M} & \frac{k_2}{M} & -\frac{(b_1-b_2)}{M} & -\frac{(b_1-b_2)l}{2M} & \frac{b_1}{M} & \frac{b_2}{M} \\ -\frac{(k_1-k_2)l}{2J} & -\frac{(k_1+k_2)l^2}{4J} & \frac{k_1L}{2J} & -\frac{k_2 l}{2J} & -\frac{(b_1-b_2)L}{2J} & -\frac{(b_1-b_2)L^2}{4J} & \frac{b_1L}{2J} & -\frac{b_2L}{2J} \\ \frac{k_1}{m_1} & \frac{k_1L}{2m_1} & -\frac{k_1 \cdot 2}{m_1} & 0 & \frac{b_1}{m_1} & \frac{b_1L}{2m_1} & -\frac{b_1}{m_1} & 0 \\ \frac{k_2}{m_2} & \frac{k_2L}{2m_2} & 0 & -\frac{k_2 \cdot 2}{m_2} & \frac{b_2}{m_2} & 0 & 0 & -\frac{b_2}{m_2} \end{bmatrix}$$

$$B = \begin{bmatrix} 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ k_1/m_1 & 0 \\ 0 & k_2/m_2 \end{bmatrix} \qquad u = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ z(t) \\ z(t+\alpha \end{bmatrix} \qquad \dot{x} = Ax + Bu$$

⑤ $$\dot{x} = \begin{bmatrix} \dot{x} \\ \dot{\theta} \\ \ddot{x} \\ \ddot{\theta} \end{bmatrix} \qquad \begin{cases} (m+M)\ddot{x} + ml\ddot{\theta} = u \\ J\ddot{\theta} + ml\ddot{x} = mgl\theta \end{cases}$$

$$A = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & \frac{-m^2 l^2}{J(M+m)+m^2 l^2} & 0 & 0 \\ 0 & \frac{mgl(m+M)}{J(M+m)^2+m^2 l^2} & 0 & 0 \end{bmatrix} \qquad B = \begin{bmatrix} 0 \\ 0 \\ \frac{1}{(M+m) - m^2 l^2/4} \\ -mgl/J(M+m) - m^2 l^2 \end{bmatrix}$$

(6) $M\ddot{x} = mg - \frac{kI^2}{x^2}$ $\qquad X = \begin{bmatrix} x \\ \dot{x} \\ I \end{bmatrix}$ $\qquad u = V$

$L\dot{I} + RI = V$

$$A = \begin{bmatrix} 0 & 1 & 0 \\ \frac{2KIeq^2}{m x_{eq}^3} & 0 & \frac{-2Keq}{m x_{eq}^2} \\ 0 & 0 & -R/I \end{bmatrix} \qquad B = \begin{bmatrix} 0 \\ 0 \\ \frac{1}{L} \end{bmatrix} \qquad \dot{X} = AX + B$$