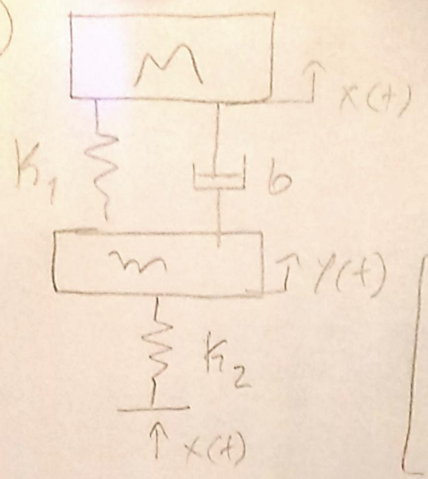
2)

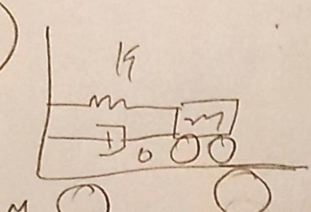


$$M\ddot{x} + k_1(x-y) + b(\dot{x}-\dot{y}) = 0$$

$$m\ddot{y} - k_1(x-y) - b(\dot{x}-\dot{y}) + k_2(y-z) = 0$$

$$\begin{bmatrix} \dot{x} \\ \dot{y} \\ \ddot{x} \\ \ddot{y} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ -\frac{k_1}{M} & \frac{k_1}{M} & \frac{-b}{M} & \frac{b}{M} \\ \frac{k_1}{m} & \frac{-k_1-k_2}{m} & \frac{b}{m} & \frac{-b}{m} \end{bmatrix} \begin{bmatrix} x \\ y \\ \dot{x} \\ \dot{y} \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 0 \\ \frac{k_2}{m} \end{bmatrix} z(t)$$

3)



$$m\ddot{y} + k(y-x) + b(\dot{y}-\dot{x}) = 0$$

$$M\ddot{x} - k(y-x) - b(\dot{y}-\dot{x}) = u$$

$$\begin{bmatrix} \dot{x} \\ \dot{y} \\ \ddot{x} \\ \ddot{y} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ \frac{-k}{m} & \frac{k}{m} & \frac{-b}{M} & \frac{b}{M} \\ \frac{k}{m} & \frac{-k}{m} & \frac{b}{m} & \frac{-b}{m} \end{bmatrix} \begin{bmatrix} x \\ y \\ \dot{x} \\ \dot{y} \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ \frac{1}{M} \\ 0 \end{bmatrix} u(t)$$

4)

$$X = [x_1, x_2, x_6, \theta, \dot{x}_1, \dot{x}_2, \dot{x}_6, \dot{\theta}]^T \qquad X = AX + BU$$

$$\dot{X} = [\dot{x}_1, \dot{x}_2, \dot{x}_6, \dot{\theta}, \ddot{x}_1, \ddot{x}_2, \ddot{x}_6, \ddot{\theta}]^T$$

$$A = \begin{bmatrix} 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 6 & 0 & 0 & 0 & 1 \\ -\frac{(k+k_2)}{m_1} & 0 & \frac{k_1}{m_1} & \frac{k_2 l}{m} & -\frac{k_1}{m_1} & 0 & \frac{b_1}{m_1} & \frac{bl}{m} \\ 0 & -\frac{k_1 k}{l} & \frac{k_2}{m_2} & \frac{k_2 l}{m_2} & 0 & \frac{bl}{m_2} & \frac{b_2}{m_2} & \frac{bl}{m_2} \\ \frac{k_1}{m} & \frac{k_2}{m} & -\frac{(k_2+k_1)}{m} & \frac{k_2-k_1}{m} l & \frac{b_1}{m} & \frac{b_2}{m} & \frac{-b_1-b_2}{m} & \frac{b_2-b_1}{m} l \\ \frac{k_1 l}{J} & -\frac{k_2 l}{J} & \frac{l(k_2-k_1)}{J} & -\frac{l^2(k_2+k_1)}{J} & \frac{b_1 l}{J} & -\frac{b_2 l}{J} & \frac{l(b_2-b_1)}{J} & -\frac{l^2(b_2+b_1)}{J} \end{bmatrix}$$

3) $X = [x, \theta, \dot{x}, \dot{\theta}]^T \Rightarrow \dot{X} = [\dot{x}, \dot{\theta}, \ddot{x}, \ddot{\theta}]^T$

$(m+M)\ddot{x} + ml\ddot{\theta} = u$; $J\ddot{\theta} + ml\ddot{x} - mgl\theta = 0$

$$A \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & \frac{-m^2l^2}{J(M+m)-m^2l^2} & 0 & 0 \\ 0 & \frac{mgl(M+m)}{J(M+m)^2 m^2 l^2} & 0 & 6 \end{bmatrix} ; \quad B = \begin{bmatrix} 0 \\ 0 \\ \frac{1}{M+m-\frac{m^2l^2}{u}} \\ \frac{-mgl}{J(M+m)-m^2l^2} \end{bmatrix}$$

6) $m\ddot{x} = mg - \frac{kI^2}{x^2}$; $L\dot{I} + RI = V$

$X = [x, \dot{x}, I]^T$ e $u = V$

$$A = \begin{bmatrix} \frac{\partial \dot{x}}{\partial x} & \frac{\partial \dot{x}}{\partial x} & \frac{\partial \ddot{x}}{\partial I} \\ \frac{\partial \ddot{x}}{\partial x} & \frac{\partial \ddot{x}}{\partial \dot{x}} & \frac{\partial \ddot{x}}{\partial I} \\ \frac{\partial \dot{I}}{\partial x} & \frac{\partial \dot{I}}{\partial \dot{x}} & \frac{\partial \dot{I}}{\partial I} \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ \frac{2kI_0^2}{mV_0^3} & 0 & \frac{-2kI_0}{mx_0^2} \\ 0 & 0 & -\frac{R}{L} \end{bmatrix}$$

$$B = \begin{bmatrix} 0 \\ 0 \\ \frac{1}{L} \end{bmatrix} \qquad \dot{x} = Ax + Bu$$