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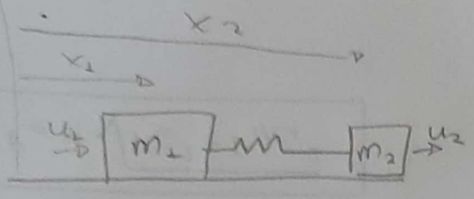


$$\begin{cases} \bar{x} = \dfrac{m_1 x_1 + m_2 x_2}{m_1 + m_2} = \dfrac{m_1 x_1 + m_2 x_2}{M} \\ \delta = x_1 - x_2 \end{cases}$$

→ Sist. Dinâmico

$$\begin{cases} \ddot{\bar{x}} = \dfrac{u_1 + u_2}{M} \\ \ddot{\delta} = -\dfrac{KM}{M_1 M_2}\delta + \dfrac{u_1}{M_1} - \dfrac{u_2}{M_2} \end{cases}$$

→ Espaço de Estados

$$\begin{bmatrix} \dot{\bar{x}} \\ \dot{\delta} \\ \ddot{\bar{x}} \\ \ddot{\delta} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 \\ 0 & -\frac{KM}{M_1 M_2} & 0 & 0 \end{bmatrix} \begin{bmatrix} \bar{x} \\ \delta \\ \dot{\bar{x}} \\ \dot{\delta} \end{bmatrix} + \begin{bmatrix} 0 & 0 \\ 0 & 0 \\ 1/M & 1/M \\ 1/m_1 & -1/m_2 \end{bmatrix} \begin{bmatrix} u_1 \\ u_2 \end{bmatrix} \Rightarrow \dot{z} = Az + Bu$$

→ Com variáveiss $\bar{x}$ e $\delta$

$$\begin{bmatrix} \bar{x} \\ \delta \end{bmatrix} = \begin{bmatrix} \frac{m_1}{M} & \frac{m_2}{M} \\ 1 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

$$\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \frac{1}{-\frac{M_1 - M_2}{M}} \begin{bmatrix} -1 & -\frac{M_2}{M} \\ -1 & \frac{M_1}{M} \end{bmatrix} \begin{bmatrix} \bar{x} \\ \delta \end{bmatrix} \Rightarrow \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 1 & \frac{M_2}{M} \\ 1 & -\frac{M_1}{M} \end{bmatrix} \begin{bmatrix} \bar{x} \\ \delta \end{bmatrix}$$

$$\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 1 & \frac{M_2}{M} & 0 & 0 \\ 1 & -\frac{M_1}{M} & 0 & 0 \end{bmatrix} \begin{bmatrix} \bar{X} \\ \delta \\ \dot{\bar{X}} \\ \dot{\delta} \end{bmatrix} \rightsquigarrow \underline{\underline{Y = \bar{C} z}}$$

$$\begin{cases} \dot{z} = Az + Bu \\ Y = \bar{C} z \end{cases}$$