Enzo C. Zugliani - 10333741

Equações:

- $\bar{x} = (M_1 x_1 + M_2 x_2)\frac{1}{M}$, $\delta = x_1 - x_2$

- $\ddot{\bar{x}} = (u_1 + u_2)\frac{1}{M}$, $\ddot{\delta} = -\frac{KM}{M_1 M_2}\delta + \frac{u_1}{M_1} - \frac{u_2}{M_2}$

- $z = [\bar{x} \quad \delta \quad \dot{\bar{x}} \quad \dot{\delta}]^T$
- $\dot{z} = [\dot{\bar{x}} \quad \dot{\delta} \quad \ddot{\bar{x}} \quad \ddot{\delta}]^T$

- Reescrevendo:
  - $\dot{\bar{x}} = 0 \cdot \bar{x} + 0 \cdot \delta + 1 \cdot \dot{\bar{x}} + 0 \cdot \dot{\delta} + 0 u_1 + 0 u_2$
  - $\dot{\delta} = 0 \cdot \bar{x} + 0 \cdot \delta + 0 \cdot \dot{\bar{x}} + 1 \dot{\delta} + 0 u_1 + 0 u_2$
  - $\ddot{\bar{x}} = 0 \cdot \bar{x} + 0 \delta + 0 \dot{\bar{x}} + 0 \dot{\delta} + \frac{1}{M} u_1 + \frac{1}{M} u_2$
  - $\ddot{\delta} = 0 \cdot \bar{x} - \frac{KM}{M_1 M_2}\delta + 0 \dot{\bar{x}} + 0 \dot{\delta} + \frac{1}{M_1} u_1 - \frac{1}{M_2} u_2$

- Encontrando x_1 e x_2 em função de $\bar{x}$ e δ:
  - $\bar{x} = (M_1 \cdot x_1 + M_2 \cdot (x_1 - \delta))\frac{1}{M} = (M x_1 - M_2 \delta)\frac{1}{M} \Rightarrow$
    $\Rightarrow \bar{x} = x_1 - \frac{M_2}{M} \cdot \delta$; $x_1 = \bar{x} + \frac{M_2}{M}\delta$
  - $\bar{x} = (M_1 \cdot (\delta + x_2) + M_2 x_2)\frac{1}{M} = (M_1 \delta + M x_2)\frac{1}{M} = \bar{x} \Rightarrow$
    $\Rightarrow \bar{x} = x_2 + \frac{M_2}{M} \cdot \delta$; $x_2 = \bar{x} + \frac{M_2}{M}\delta$

- Assim, na forma matricial:

$$\begin{bmatrix} \dot{\bar{x}} \\ \dot{\delta} \\ \ddot{\bar{x}} \\ \ddot{\delta} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 \\ 0 & -\frac{KM}{M_1 M_2} & 0 & 0 \end{bmatrix} \cdot \begin{bmatrix} \bar{x} \\ \delta \\ \dot{\bar{x}} \\ \dot{\delta} \end{bmatrix} + \begin{bmatrix} 0 & 0 \\ 0 & 0 \\ \frac{1}{M} & \frac{1}{M} \\ \frac{1}{M_1} & \frac{-1}{M_2} \end{bmatrix} \cdot \begin{bmatrix} u_1 \\ u_2 \end{bmatrix}$$

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} 1 & \frac{M_2}{M} & 0 & 0 \\ 1 & -\frac{M_1}{M} & 0 & 0 \end{bmatrix} \cdot \begin{bmatrix} \bar{x} \\ \delta \\ \dot{\bar{x}} \\ \dot{\delta} \end{bmatrix}$$