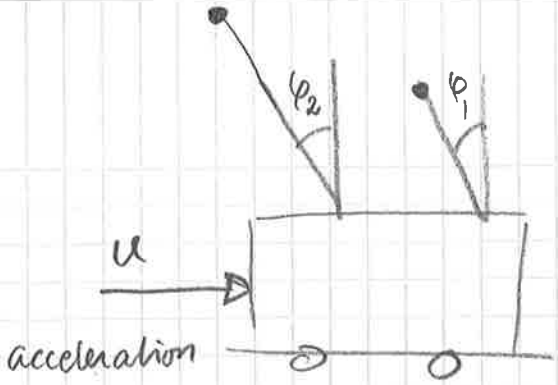

styrbart?

$$\begin{cases} \ddot{\varphi}_1 = \alpha_1 \varphi_1 + \alpha_1 u \\ \ddot{\varphi}_2 = \alpha_2 \varphi_2 + \alpha_2 u \\ \ddot{x} = u \end{cases} \qquad \alpha_1 \sim \frac{1}{\ell_1} > 0 \qquad \alpha_2 \sim \frac{1}{\ell_2} > 0$$

$$\begin{cases} x_1 = \varphi_1 \\ x_2 = \varphi_2 \\ x_3 = \dot{\varphi}_1 \\ x_4 = \dot{\varphi}_2 \end{cases} \qquad \begin{aligned} \dot{x}_1 &= x_3 \\ \dot{x}_2 &= x_4 \\ \dot{x}_3 &= \alpha_1 x_1 + \alpha_1 u \\ \dot{x}_4 &= \alpha_2 x_2 + \alpha_2 u \end{aligned}$$

dvs $\dot{x} = Ax + Bu$ med

$$A = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ \alpha_1 & 0 & 0 & 0 \\ 0 & \alpha_2 & 0 & 0 \end{bmatrix} \qquad B = \begin{bmatrix} 0 \\ 0 \\ \alpha_1 \\ \alpha_2 \end{bmatrix}$$

$$W = [B \; AB \; A^2B \; A^3B] = \begin{bmatrix} 0 & \alpha_1 & 0 & \alpha_1^2 \\ 0 & \alpha_2 & 0 & \alpha_2^2 \\ \alpha_1 & 0 & \alpha_1^2 & 0 \\ \alpha_2 & 0 & \alpha_2^2 & 0 \end{bmatrix}$$

byt plats

inverterbar?

$$\det W = -\det \begin{bmatrix} \alpha_1^2 & \alpha_1 & 0 & 0 \\ \alpha_2^2 & \alpha_2 & 0 & 0 \\ 0 & 0 & \alpha_1^2 & \alpha_1 \\ 0 & 0 & \alpha_2^2 & \alpha_2 \end{bmatrix} = -\alpha_1^2\alpha_2^2(\alpha_1-\alpha_2)^2 \neq 0 \text{ om } \alpha_1 \neq \alpha_2$$

linjärt oberoende kol. om $\alpha_1 \neq \alpha_2$

ty $\det \begin{bmatrix} \alpha_1^2 & \alpha_1 \\ \alpha_2^2 & \alpha_2 \end{bmatrix} = \alpha_1\alpha_2(\alpha_1-\alpha_2)$

styrbart!