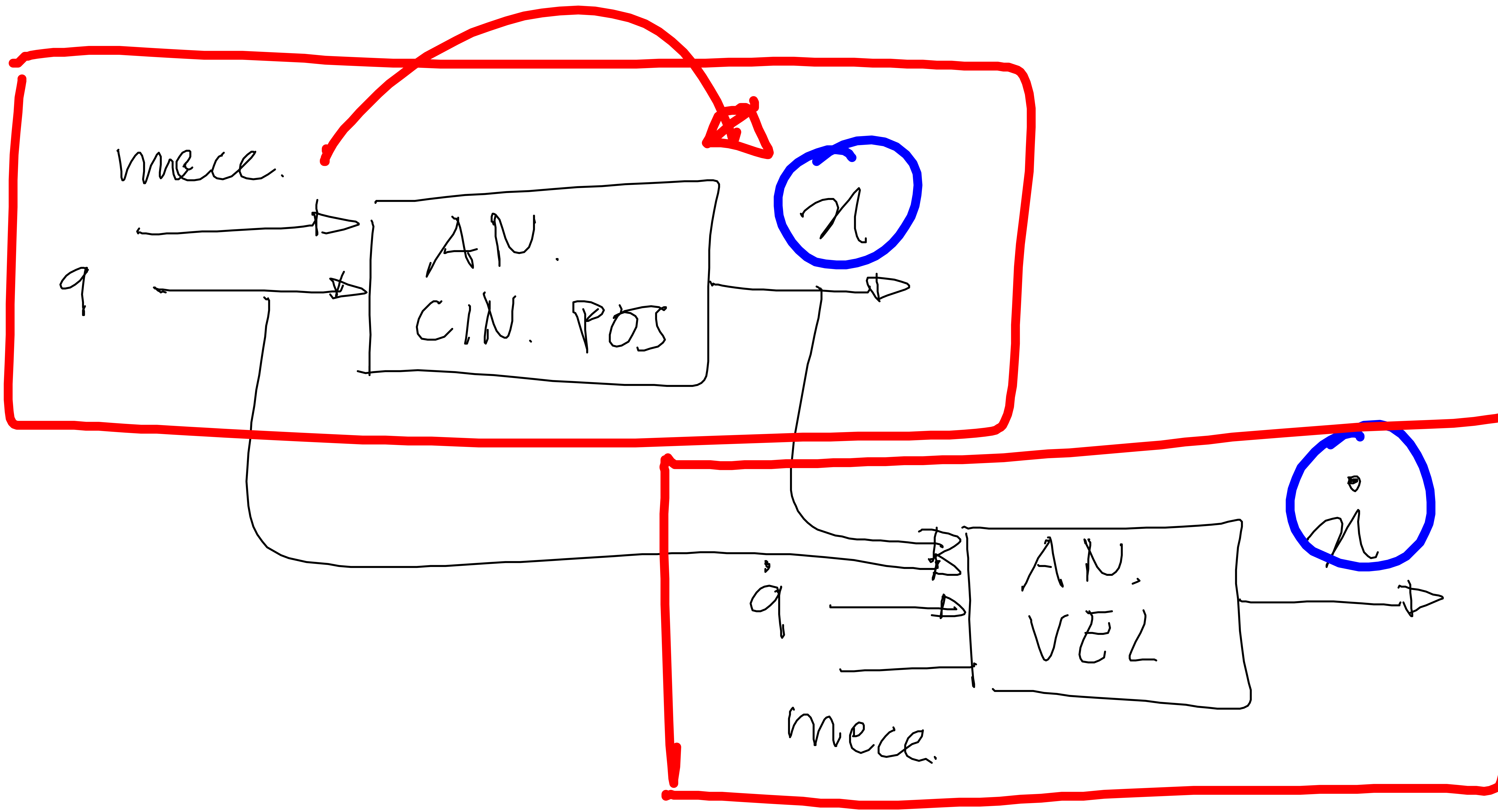

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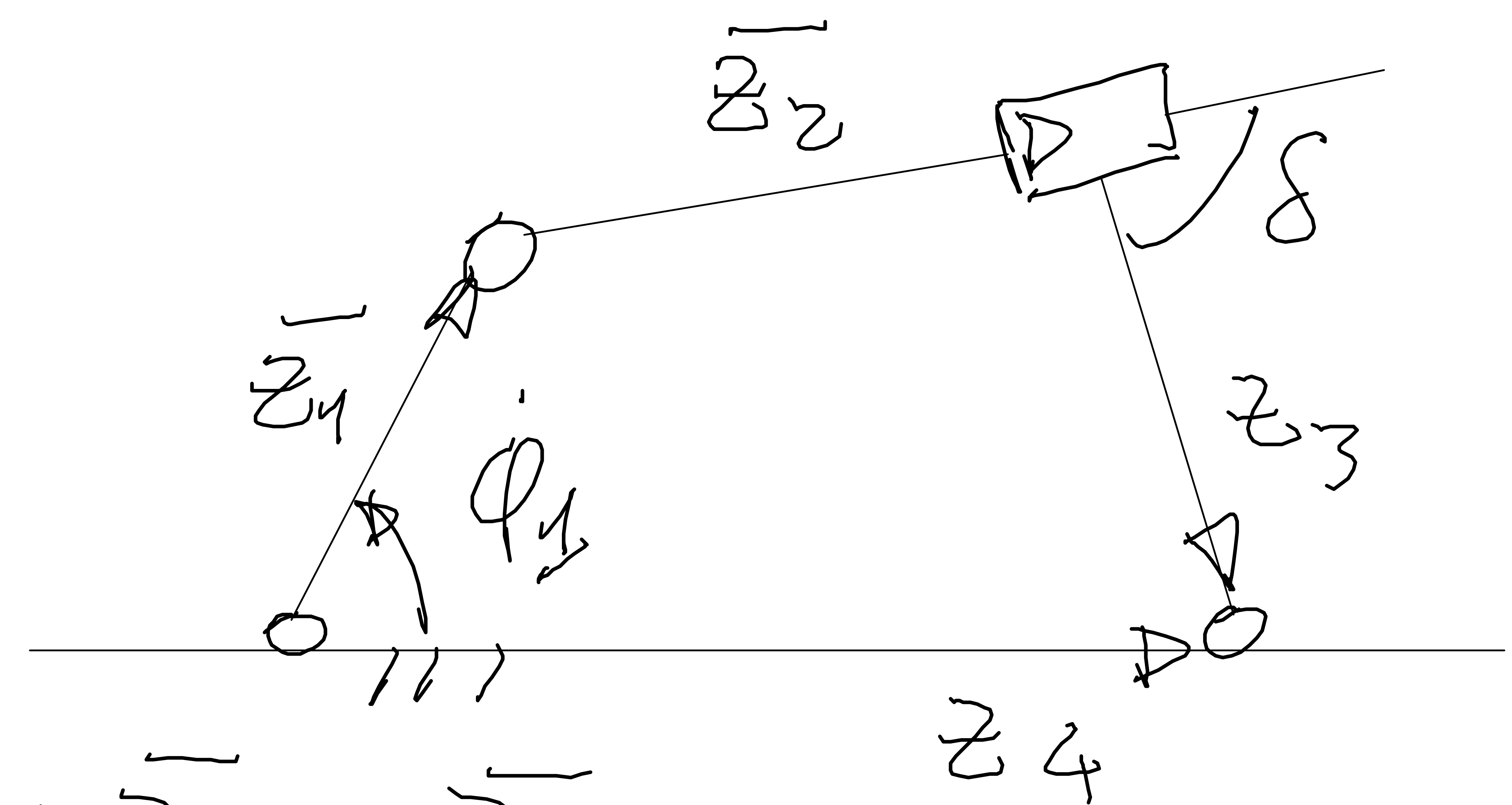


$$\varphi_3 = \varphi_2 - \delta$$

$$\bar{z}_1 + \bar{z}_2 + \bar{z}_3 - \bar{z}_4 = 0$$

$$\begin{cases} z_1 c\varphi_1 + z_2 c\varphi_2 + z_3 c(\varphi_2 - \delta) - z_4 = 0 \\ z_1 s\varphi_1 + z_2 s\varphi_2 + z_3 s(\varphi_2 - \delta) = 0 \end{cases}$$

$$\begin{cases} -z_1 s\varphi_1 \dot{\varphi}_1 + \dot{z}_2 c\varphi_2 - z_2 s\varphi_2 \dot{\varphi}_2 - z_3 s(\varphi_2 - \delta)\dot{\varphi}_2 = 0 \\ z_1 c\varphi_1 \dot{\varphi}_1 + \dot{z}_2 s\varphi_2 + z_2 c\varphi_2 \dot{\varphi}_2 + z_3 c(\varphi_2 - \delta)\dot{\varphi}_2 = 0 \end{cases}$$

$$\underbrace{\begin{bmatrix} -z_2 s\varphi_2 - z_3 s(\varphi_2-\delta) & c\varphi_2 \\ z_2 c\varphi_2 + z_3 c(\varphi_2-\delta) & s\varphi_2 \end{bmatrix}}_{J} \underbrace{\begin{Bmatrix}\dot\varphi_2 \\ \dot z_2\end{Bmatrix}}_{\dot x} + \underbrace{\begin{Bmatrix} -z_1 s\varphi_1 \\ z_1 c\varphi_1\end{Bmatrix}}_{A} \underbrace{\dot\varphi_1}_{\dot q} = 0$$

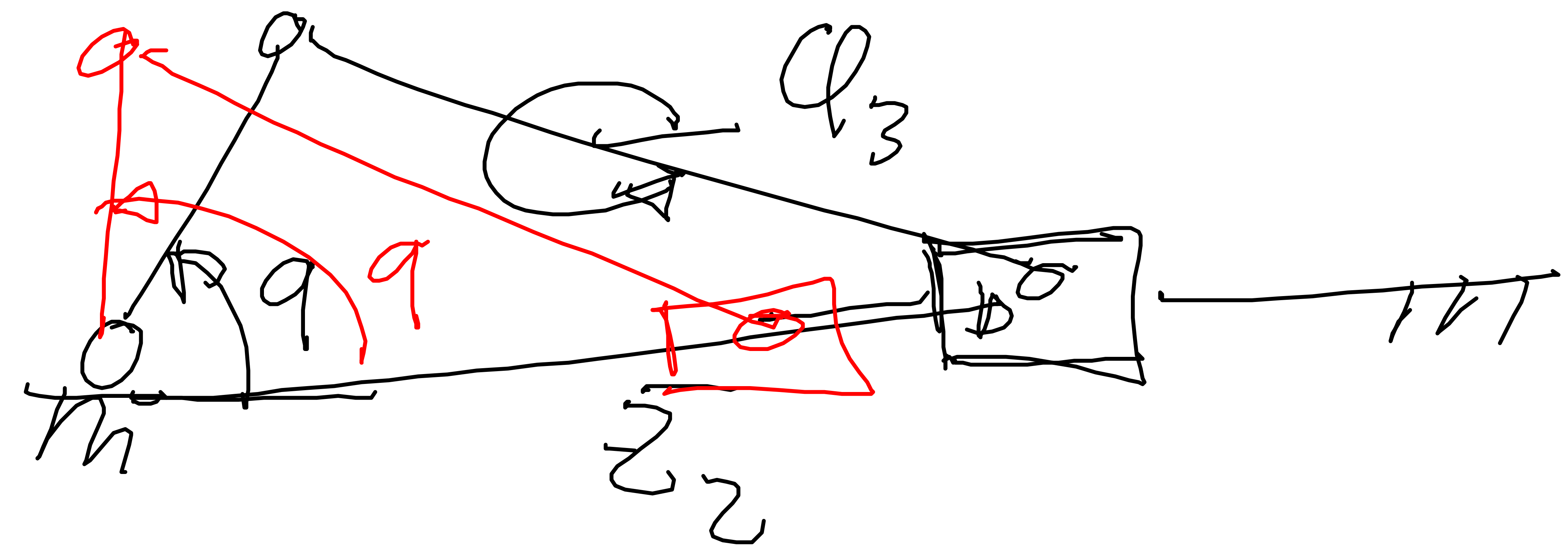
$$\boxed{J\dot x + A\dot q = 0}$$

$$\dot x = \begin{Bmatrix}\dot\varphi_2 \\ \dot z_2\end{Bmatrix} = -J^{-1}A\dot q$$

$$\begin{array}{c c} & 2m \\ 2m & \begin{bmatrix} J(q) \end{bmatrix} \end{array} \begin{array}{c} 2m \\ \begin{Bmatrix} \dot x \end{Bmatrix} \end{array} + \begin{array}{c} n \\ \begin{bmatrix} A(q) \\ 2m \end{bmatrix} \end{array} \begin{array}{c} n \\ \begin{Bmatrix} \dot q \end{Bmatrix} \end{array} = 0$$

$n = \#$ GDL

$m = \#$ eq. chiusura



$$\dot{q} \longrightarrow \boxed{} \longrightarrow \begin{Bmatrix} \dot{z}_2 \\ \dot{\varphi}_3 \end{Bmatrix}$$

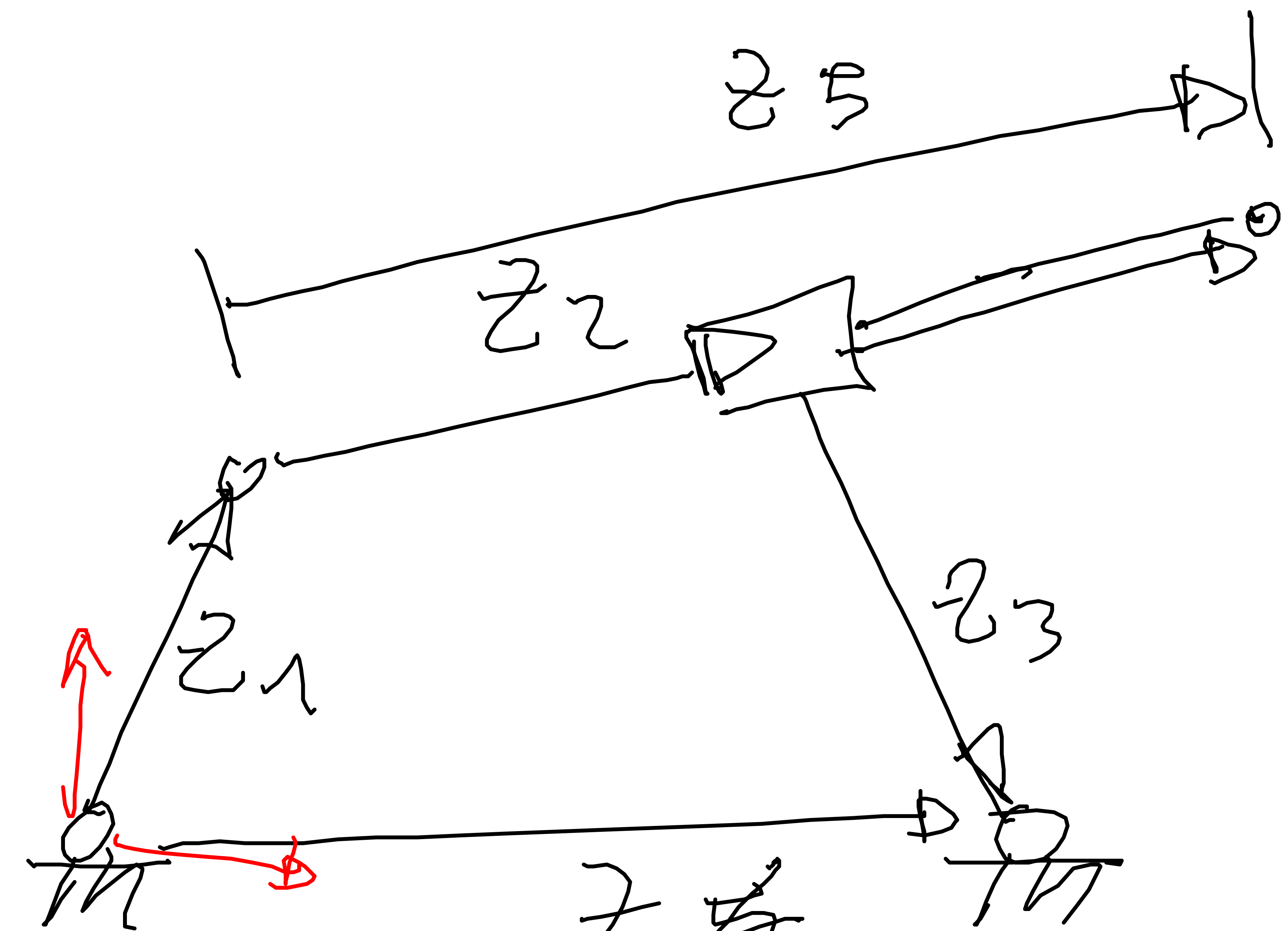
$$\varphi_5 = \varphi_2$$

$$\dot{x}$$

$$P = \bar{z}_1 + \ldots + \bar{z}_k =$$

$$= \begin{Bmatrix} z_1 c\varphi_1 + \ldots + z_k c\varphi_k \\ z_1 s\varphi_1 + z_k s\varphi_k \end{Bmatrix}$$

$$\dot{p} = \begin{bmatrix} c\varphi_1 & -z_1 s\varphi_1 \\ s\varphi_1 & z_1 c\varphi_1 \end{bmatrix} \begin{Bmatrix} \dot{z}_1 \\ \dot{\varphi}_1 \end{Bmatrix} + \ldots + \begin{bmatrix} c\varphi_k & -z_k s\varphi_k \\ s\varphi_k & z_k c\varphi_k \end{bmatrix} \begin{Bmatrix} \dot{z}_k \\ \dot{\varphi}_k \end{Bmatrix}$$



$$P = \underline{\bar{z}_1} + \underline{\bar{z}_5}$$