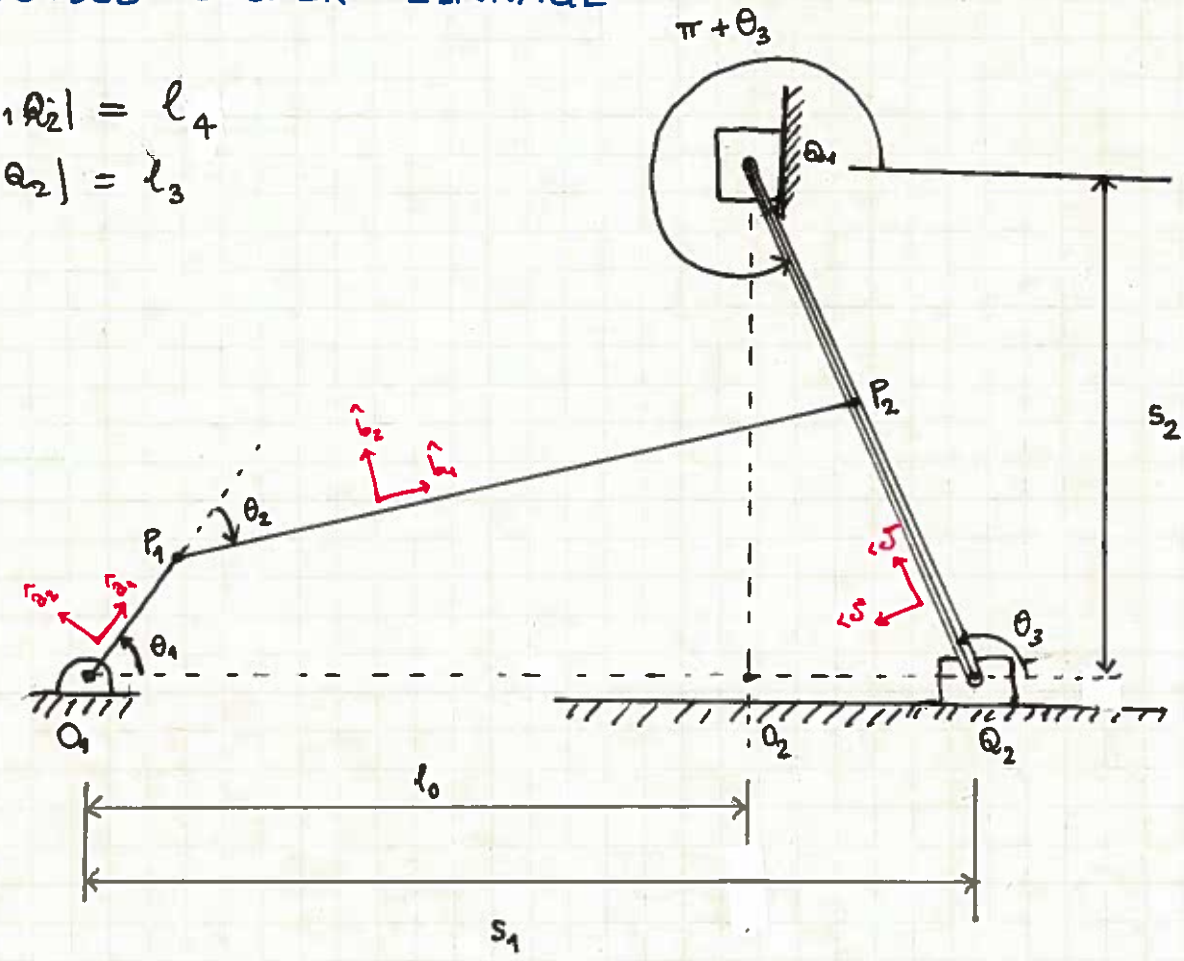
DOUBLE SLIDER LINKAGE

$|Q_1 P_1| = \ell_4$

$|P_2 Q_2| = \ell_3$



Position level

$$\ell_1 \hat{a}_1 + \ell_2 \hat{b}_1 = \ell_3 \hat{c}_1 - s_1 \hat{e}_1 = 0 \Rightarrow \ell_1 \begin{pmatrix} c_{\theta_1} \\ s_{\theta_1} \end{pmatrix} + \ell_2 \begin{pmatrix} c_{\theta_{12}} \\ s_{\theta_{12}} \end{pmatrix} - \ell_3 \begin{pmatrix} c_{\theta_3} \\ s_{\theta_3} \end{pmatrix} - \begin{pmatrix} s_1 \\ 0 \end{pmatrix} = 0$$

$$\ell_0 \hat{e}_1 + s_2 \hat{e}_2 - \ell_4 \hat{c}_1 - s_1 \hat{e}_1 = (\ell_0 - s_1)\hat{e}_1 + s_2 \hat{e}_2 - \ell_4 \hat{c}_1 = 0$$

$$\Rightarrow \begin{pmatrix} \ell_0 - s_1 \\ 0 \end{pmatrix} + \begin{pmatrix} 0 \\ s_2 \end{pmatrix} - \ell_4 \begin{pmatrix} c_{\theta_3} \\ s_{\theta_3} \end{pmatrix} = 0 .$$

Velocity level

$$\ell_1 \dot{\theta}_1 \begin{pmatrix} -s_{\theta_1} \\ c_{\theta_1} \end{pmatrix} + \ell_2 (\dot{\theta}_1 + \dot{\theta}_2) \begin{pmatrix} -s_{\theta_{12}} \\ c_{\theta_{12}} \end{pmatrix} - \ell_3 \dot{\theta}_3 \begin{pmatrix} -s_{\theta_3} \\ c_{\theta_3} \end{pmatrix} - \begin{pmatrix} \dot{s}_1 \\ 0 \end{pmatrix} = 0$$

$$\begin{pmatrix} -\dot{s}_1 \\ 0 \end{pmatrix} + \begin{pmatrix} 0 \\ \dot{s}_2 \end{pmatrix} - \ell_4 \dot{\theta}_3 \begin{pmatrix} -s_{\theta_3} \\ c_{\theta_3} \end{pmatrix} = 0$$

Acceleration level

$$\ell_1 \ddot{\theta}_1 \begin{pmatrix} -s_{\theta_1} \\ c_{\theta_1} \end{pmatrix} - \ell_1 \dot{\theta}_1^2 \begin{pmatrix} c_{\theta_1} \\ s_{\theta_1} \end{pmatrix} + \ell_2 (\ddot{\theta}_1 + \ddot{\theta}_2) \begin{pmatrix} -s_{\theta_{12}} \\ c_{\theta_{12}} \end{pmatrix} - \ell_2 (\dot{\theta}_1 + \dot{\theta}_2)^2 \begin{pmatrix} c_{\theta_{12}} \\ s_{\theta_{12}} \end{pmatrix} - \ell_3 \ddot{\theta}_3 \begin{pmatrix} -s_{\theta_3} \\ c_{\theta_3} \end{pmatrix} + \ell_3 \dot{\theta}_3^2 \begin{pmatrix} c_{\theta_3} \\ s_{\theta_3} \end{pmatrix} - \begin{pmatrix} \ddot{s}_1 \\ 0 \end{pmatrix} = 0$$

$$\begin{pmatrix} -\ddot{s}_1 \\ 0 \end{pmatrix} + \begin{pmatrix} 0 \\ \ddot{s}_2 \end{pmatrix} - \ell_4 \ddot{\theta}_3 \begin{pmatrix} -s_{\theta_3} \\ c_{\theta_3} \end{pmatrix} + \ell_4 \dot{\theta}_3^2 \begin{pmatrix} c_{\theta_3} \\ s_{\theta_3} \end{pmatrix} = 0$$