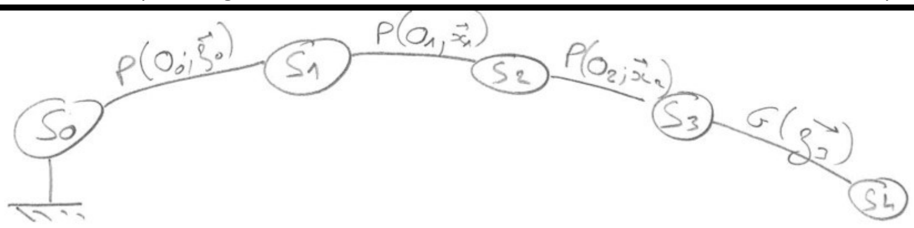
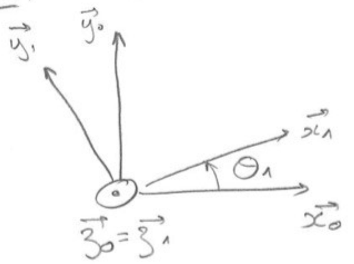
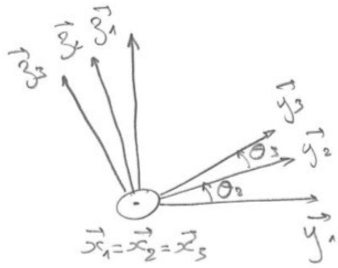


Q2/3

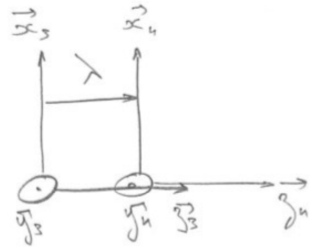


$$\vec{\Omega}_{1/0} = \dot{\theta}_1 \vec{z}_{0}$$



$$\vec{\Omega}_{2/1} = \dot{\theta}_2 \, \vec{x}_{1,2,3}$$

$$\vec{\Omega}_{3/2} = \dot{\theta}_3 \, \vec{x}_{1,2,3}$$



$$\vec{\Omega}_{4/3} = \vec{0}$$

Q4

$$\vec{\Omega}_{4/0} = \vec{\Omega}_{4/3} + \vec{\Omega}_{3/2} + \vec{\Omega}_{2/1} + \vec{\Omega}_{1/0}$$

$$= (\dot{\theta}_2 + \dot{\theta}_3)\,\vec{x}_{1,2,3} + \dot{\theta}_1 \vec{z}_{0}$$

Q5 $\vec{V}_{O_1,1/0} = \vec{0}$ car $O_1 \in \Delta_{10}$ $\Rightarrow$ $\{V_{1/0}\} = \left\{ \begin{matrix} \dot{\theta}_1 \vec{z}_{0} \\ \vec{0} \end{matrix} \right\}_{O_1}$

Q6 $\vec{V}_{O_2,2/0} = \left.\dfrac{d\vec{O_1O_2}}{dt}\right|_{R_0}$ car O_1 fixe dans R_0

D'où $= \left.\dfrac{d(L_1\vec{y}_2)}{dt}\right|_{R_0} = L_1\left(\left.\dfrac{d\vec{y}_2}{dt}\right|_{R_2} + \vec{\Omega}_{2/0} \wedge \vec{y}_2\right) = L_1\left(\dot{\theta}_1\vec{z}_0 + \dot{\theta}_2\vec{x}_2\right) \wedge \vec{y}_2$

$$\vec{V}_{O_2,2/0} = L_1\left(-\dot{\theta}_1 \cos\theta_2 \vec{x}_2 + \dot{\theta}_2 \vec{z}_2\right)$$

Et $\vec{\Gamma}_{O_2,2/0} = \left.\dfrac{d\vec{V}_{O_2,2/0}}{dt}\right|_{R_0}$ avec $\left.\dfrac{d\vec{x}_2}{dt}\right|_{R_0} = \vec{\Omega}_{2/0} \wedge \vec{x}_2 = (\dot{\theta}_1 \vec{z}_0 + \dot{\theta}_2 \vec{x}_2) \wedge \vec{x}_2 = \dot{\theta}_1 \vec{y}_1$

$$\left.\frac{d\vec{z}_2}{dt}\right|_{R_0} = (\dot{\theta}_1 \vec{z}_0 + \dot{\theta}_2 \vec{x}_2) \wedge \vec{z}_2 = \left(\dot{\theta}_1 \sin\theta_2 \vec{x}_{1,2} - \dot{\theta}_2 \vec{y}_2\right)$$

D'où

$$\vec{\Gamma}_{O_2,2/0} = L_1\Big(-\ddot{\theta}_1 \cos\theta_2 \vec{x}_{2} + \dot{\theta}_1\dot{\theta}_2 \sin\theta_2 \vec{x}_{2} - \dot{\theta}_1^2 \cos\theta_2 \vec{y}_1$$
$$+ \ddot{\theta}_2 \vec{z}_2 + \dot{\theta}_2\left(\dot{\theta}_1 \sin\theta_2 \vec{x}_{1} - \dot{\theta}_2 \vec{y}_2\right)\Big)$$

De plus :

$$\{V_{2/0}\} = \left\{ \begin{matrix} \dot{\theta}_1 \vec{z}_{0} + \theta_2 \vec{x}_{1,2,3} \\ L_1\left(-\dot{\theta}_1 \cos\theta_2 \vec{x}_2 + \dot{\theta}_2 \vec{z}_2\right) \end{matrix} \right\}_{O_2}$$

$$\vec{\Gamma}_{O_2,2/0} = L_1\left[\left(-\ddot{\theta}_1 \cos\theta_2 + 2\dot{\theta}_1\dot{\theta}_2 \sin\theta_2\right)\vec{x}_{1,2} - \dot{\theta}_1^2 \cos\theta_2 \vec{y}_1 - \dot{\theta}_2^2 \vec{y}_2 + \ddot{\theta}_2 \vec{z}_2\right]$$

$\boxed{Q7}$

$$\overrightarrow{V_{O_4,4/0}} = \underset{T(\vec{z_3})}{\overrightarrow{V_{O_4,4/3}}} + \underset{R(O_2,\vec{x_2})}{\overrightarrow{V_{O_4,3/2}}} + \underset{R(O_1,\vec{x_1})}{\overrightarrow{V_{O_4,2/1}}} + \underset{R(O_0,\vec{z_0})}{\overrightarrow{V_{O_4,1/0}}}$$

avec $\circledast$ $\overrightarrow{V_{O_4,4/3}} = \dot{\lambda}\,\vec{z_3}$

$\circledast$ $\overrightarrow{V_{O_4,3/2}} = \underbrace{\cancel{\overrightarrow{V_{O_2,3/2}}}}_{\vec{0}} + \overrightarrow{O_4O_2} \wedge \overrightarrow{\Omega_{3/2}}$

$$= (-\lambda\vec{z_3} - L_2\vec{y_3}) \wedge \dot{\theta}_3\vec{x_3}$$

$$= \dot{\theta}_3(-\lambda\vec{y_3} + L_2\vec{z_3})$$

$\circledast$ $\overrightarrow{V_{O_4,2/1}} = \underbrace{\cancel{\overrightarrow{V_{O_1,2/1}}}}_{\vec{0}} + \overrightarrow{O_4O_1} \wedge \overrightarrow{\Omega_{2/1}}$

$$= (-\lambda\vec{z_3} - L_2\vec{y_3} - L_1\vec{y_2}) \wedge \dot{\theta}_2\,\vec{x}_{123}$$

$$= \dot{\theta}_2(-\lambda\vec{y_3} + L_2\vec{z_3} + L_1\vec{z_2})$$

$\circledast$ $\overrightarrow{V_{O_4,1/0}} = \overrightarrow{O_4O_0} \wedge \overrightarrow{\Omega_{1/0}}$

$$= (-\lambda\vec{z_3} - L_2\vec{y_3} - L_1\vec{y_2} - L_0\vec{z_0}) \wedge \dot{\theta}_1\vec{z_{01}}$$

$$= \dot{\theta}_1\left(\lambda\sin(\theta_2+\theta_3)\vec{x}_{123} - L_2\cos(\theta_2+\theta_3)\vec{x}_{123} - L_1\cos\theta_2\,\vec{x}_{123}\right)$$

D'où

$$\begin{aligned}\overrightarrow{V_{O_4,4/0}} = \;& \dot{\theta}_1\left[\lambda\sin(\theta_2+\theta_3) - L_2\cos(\theta_2+\theta_3) - L_1\cos\theta_2\right]\vec{x_2} \\ & + L_1\dot{\theta}_2\vec{z_2} \\ & - \lambda(\dot{\theta}_3 + \dot{\theta}_2)\vec{y_3} \\ & + \left[\dot{\lambda} + L_2(\dot{\theta}_2 + \dot{\theta}_3)\right]\vec{z_3}\end{aligned}$$

Q8

$\overrightarrow{V_{O_4,4/0}} = L_2 \dot{\theta}_2 \vec{z_2} + \dot{\lambda} \vec{z_3}$

Q9

$$= L_1 \dot{\theta}_2 \left(-\sin\theta_2 \vec{y_0} + \cos\theta_2 \vec{z_0} \right) \qquad (\underline{NB} : \theta_1 = 0)$$
$$+ \dot{\lambda} \left(-\sin(\theta_2+\theta_3) \vec{y_0} + \cos(\theta_2+\theta_3) \vec{z_0} \right)$$

Q10 D'où

$$\begin{cases} -L_1 \dot{\theta}_2 \sin\theta_2 - \dot{\lambda} \sin(\theta_2+\theta_3) = V \\ L_1 \dot{\theta}_2 \cos\theta_2 + \dot{\lambda} \cos(\theta_2+\theta_3) = 0 \end{cases}$$

Q11

$$\begin{cases} \sin a + \sin b = \dots \\ \cos a + \cos b = \dots \end{cases}$$

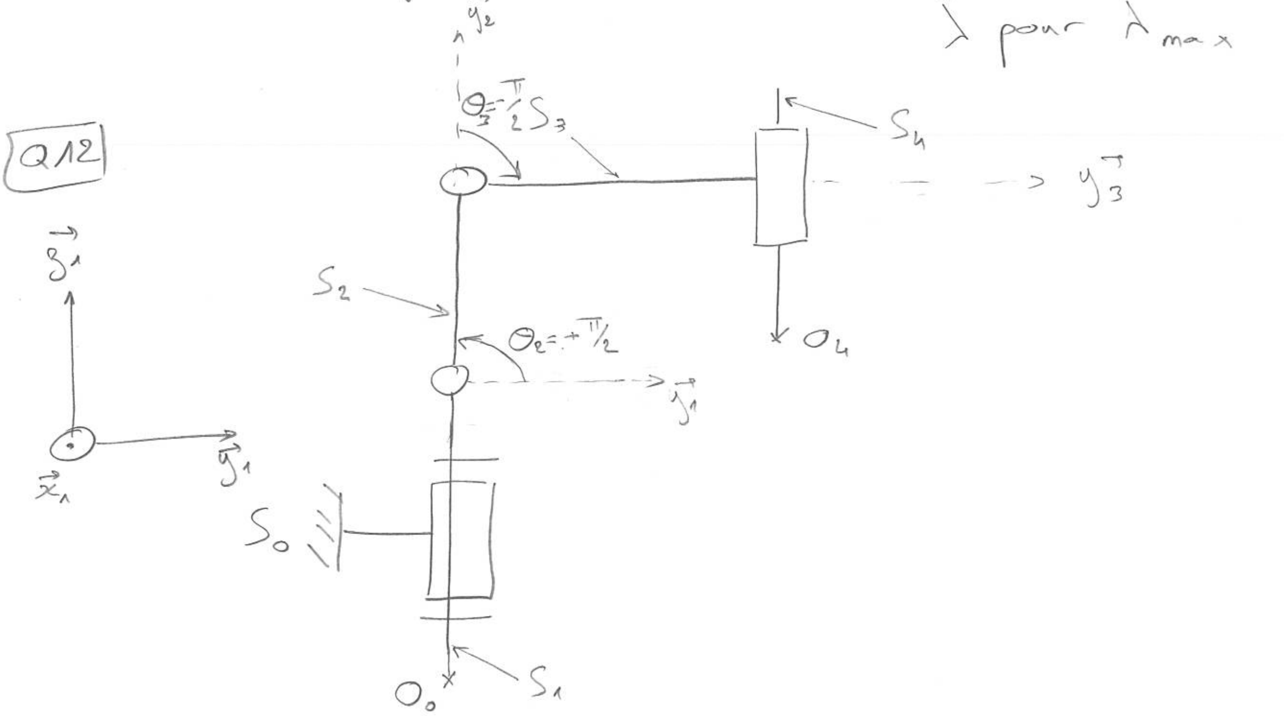
$$\Rightarrow \begin{cases} \theta_2 = f(\dot{\theta}_2, \dot{\lambda}, V) \\ \theta_3 = g(\dot{\theta}_2, \dot{\lambda}, V) \end{cases}$$

avec V connu

$\dot{\theta}_2$ pour $\dot{\theta}_{2\,max}$

$\dot{\lambda}$ pour $\dot{\lambda}_{max}$

Q12



$\boxed{Q13}$

(1) $\Rightarrow \overrightarrow{V_{O_4,4/0}} = -L_2\dot{\theta}_1 \overrightarrow{x_2} + \dot{\lambda}\overrightarrow{z_3}$

D'où

$\overrightarrow{\Gamma_{O_4,4/0}} = -L_2\left(\ddot{\theta}_1 \overrightarrow{x_{2_1}} + \dot{\theta}_1^2 \overrightarrow{y_1}\right) + \ddot{\lambda}\overrightarrow{z_3}$ avec $\overrightarrow{z_3} = \overrightarrow{z_1}$ dans cette configuration

D'où

$\left\|\overrightarrow{\Gamma_{O_4,4/0}}\right\| = \sqrt{L_2^2\left(\ddot{\theta}_1^2 + \dot{\theta}_1^4\right) + \ddot{\lambda}^2}$

AN: $L_2 = 0{,}5\ m$

$\ddot{\theta}_{1\,max} = 2\ rad.s^{-2}$

$\dot{\theta}_{1\,max} = 50\ tr/min = 50 \times \frac{2\pi}{60} \simeq 5{,}2\ rad.s^{-1}$

$\ddot{\lambda}_{max} = 1\ m.s^{-2}$

D'où

$\left\|\overrightarrow{\Gamma_{O_4,4/0}}\right\|_{max} \simeq 13{,}8\ m.s^{-2}$

$\simeq 1{,}4g < 1{,}5g \Rightarrow \boxed{\text{CDC OK}}$