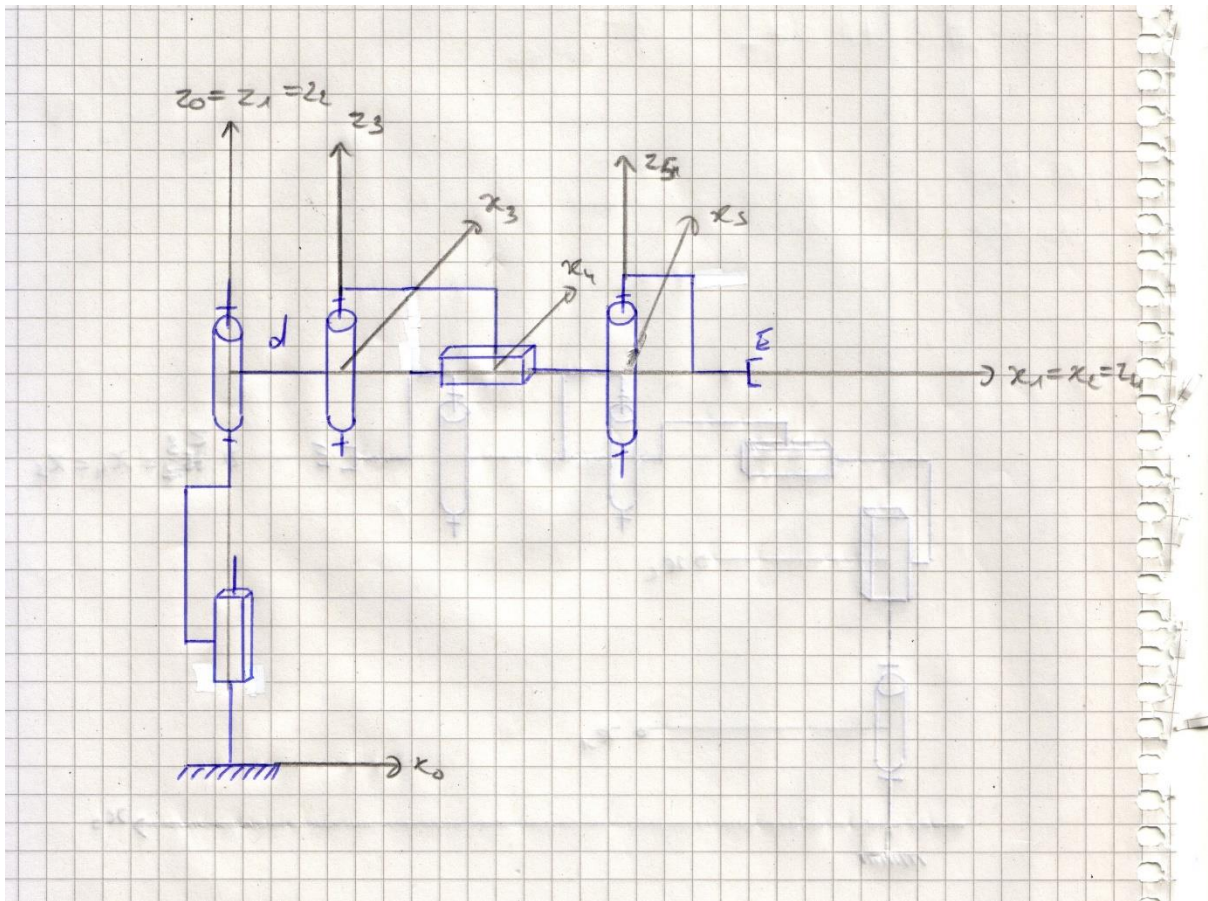


## Projet UNITY : partie Mécanique

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$\times$	$\sigma_i$	$d_i$	$\alpha_i$	$r_i$	$\theta_i$
1	1	0	0	$q_1$	0
2	0	0	0	0	$q_2$
3	0	$d$	0	0	$q_3$
4	1	0	$+90^\circ$	$q_4$	0
5	0	0	$-90^\circ$	0	$q_5$

$${}^0T_1 = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & q_1 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$${}^1T_2 = \begin{pmatrix} c_2 & -s_2 & 0 & 0 \\ s_2 & c_2 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$${}^2T_3 = \begin{pmatrix} c_3 & -s_3 & 0 & d \\ s_3 & c_3 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$${}^3T_4 = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & -1 & -q_4 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$${}^4T_5 = \begin{pmatrix} c_5 & -s_5 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ -s_5 & -c_5 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$U_4 = {}^4T_5, \quad U_3 = {}^3T_4 U_4 = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & -1 & -q_4 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} c_5 & -s_5 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ -s_5 & -c_5 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$U_3 = \begin{pmatrix} c_5 & -s_5 & 0 & 0 \\ s_5 & c_5 & 0 & -q_4 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$U_2 = {}^2T_3 U_3 = \begin{pmatrix} c_3 & -s_3 & 0 & d \\ s_3 & c_3 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$U_2 = \begin{pmatrix} c_3 c_5 - s_3 s_5 & -c_3 s_5 - s_3 c_5 & 0 & s_3 q_4 + d \\ s_3 c_5 + c_3 s_5 & c_3 s_5 - s_3 c_5 & 0 & -c_3 q_4 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$



$$U_1 = {}^1T_2 U_2 = \begin{pmatrix} C_2 & -S_2 & 0 & 0 \\ S_2 & C_2 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} U_2 \\ \\ \\ \end{pmatrix}$$

$$U_1 = \begin{pmatrix} C_2(C_3C_5 - S_3S_5) - S_2(S_3C_5 + C_3S_5) & -C_2(C_3S_5 + S_3C_5) + S_2(S_3S_5 - C_3C_5) & 0 & 0 \\ S_2(C_3C_5 - S_3S_5) + C_2(S_3C_5 + C_3S_5) & -S_2(C_3S_5 + S_3C_5) + C_2(S_3S_5 - C_3C_5) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$U_1 = \begin{pmatrix} C_2(C_3C_5 - S_3S_5) - S_2(S_3C_5 + C_3S_5) & -C_2(C_3S_5 + S_3C_5) + S_2(S_3S_5 - C_3C_5) & 0 & C_2(S_3q_2 + S_2C_3q_1) \\ S_2(C_3C_5 - S_3S_5) + C_2(S_3C_5 + C_3S_5) & -S_2(C_3S_5 + S_3C_5) + C_2(S_3S_5 - C_3C_5) & 0 & S_2(S_3q_2 + C_2C_3q_1) \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$U_0 = {}^0T_1 U_1 = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & q_1 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} U_1 \\ \\ \\ \end{pmatrix}$$

$$U_0 = \begin{pmatrix} U_1 & & & \\ 0 & 0 & 1 & q_1 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

On simplification:  $C_3C_5 - S_3S_5 = \cos(q_3 + q_5)$

$S_3C_5 + C_3S_5 = \sin(q_3 + q_5)$

$S_3S_5 - C_3C_5 = -\cos(q_3 + q_5)$

$$\text{ie } U_0 = \begin{pmatrix} C_2 \cos(q_3 + q_5) - S_2 \sin(q_3 + q_5) & -C_2 \sin(q_3 + q_5) - S_2 \cos(q_3 + q_5) & 0 & \dots \\ S_2 \cos(q_3 + q_5) + C_2 \sin(q_3 + q_5) & -S_2 \sin(q_3 + q_5) + C_2 \cos(q_3 + q_5) & 0 & \dots \\ 0 & 0 & 1 & q_1 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$U_0 = \begin{pmatrix} \cos(q_2 + q_3 + q_5) & -\sin(q_2 + q_3 + q_5) & 0 & q_1(\sin(q_2 + q_3) + C_2) \\ \sin(q_2 + q_3 + q_5) & \cos(q_2 + q_3 + q_5) & 0 & -q_1 \cos(q_2 + q_3) + S_2 C_2 \\ 0 & 0 & 1 & q_1 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

On pose  $P = \begin{pmatrix} P_x \\ P_y \\ P_z \\ \alpha \end{pmatrix}$

$$\alpha = q_2 + q_3 + q_5$$

$$P_z = q_1$$

$$\begin{cases} P_x = q_4 \sin(q_2 + q_3) + \cos(q_2) d \\ P_y = -q_4 \cos(q_2 + q_3) + \sin(q_2) d \end{cases}$$