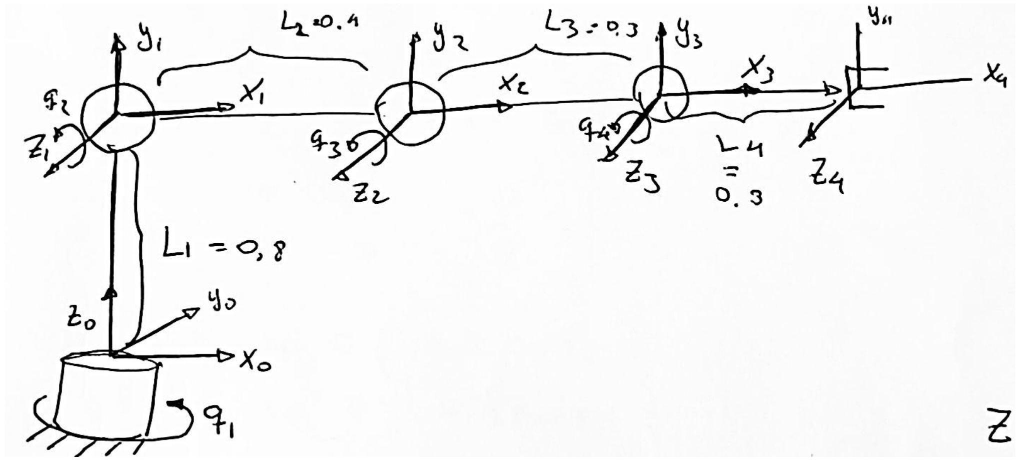

	Z		**X**	
	$\boldsymbol{Q_i}$	$\boldsymbol{d_i}$	$\boldsymbol{a_i}$	$\boldsymbol{\alpha_i}$
1	q_1	L_1	0	90°
2	q_2	0	L_2	0
3	q_3	0	L_3	0
4	q_4	0	L_4	0

L1=0.8

L2=0.4 L3=L4=0.3

$$A_1 = \begin{bmatrix} \cos(q_1) & -\sin(q_1) * \cos(90) & \sin(q_1) * \sin(90) & 0 \\ sen(q1) & \cos(q_1) * \cos(90) & -\cos(q_1) * \sin(90) & 0 \\ 0 & sin\,90 & \cos 90 & L1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A_1 = \begin{bmatrix} \cos\,(q_1) & 0 & \sin(q_1) * \sin\,(90) & 0 \\ sen(q_1) & 0 & -\cos(q_1) * \sin\,(90) & 0 \\ 0 & 1 & 0 & 0.8 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A_2 = \begin{bmatrix} \cos\,(q_2) & -\sin(q_2) & 0 & 0.4 * \cos\,(q_2) \\ sen(q_2) & \cos(q_2) & 0 & 0.4 * \sin\,(q_2) \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A_3 = \begin{bmatrix} \cos\,(q_3) & -\sin(q_3) & 0 & 0.3 * \cos\,(q_3) \\ sen(q_3) & \cos(q_3) & 0 & 0.3 * \sin\,(q_3) \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A_4 = \begin{bmatrix} \cos\,(q_4) & -\sin(q_4) & 0 & 0.3 * \cos\,(q_4) \\ sen(q_4) & \cos(q_4) & 0 & 0.3 * \sin\,(q_4) \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T = A_1 * A_2 * A_3 * A_4$$

$$T = \begin{bmatrix} \cos(q_1) * \cos(q_2 + q_3 + q_4) & -\cos(q1) * \sin(q_2 + q_3 + q_4) & \sin q_1 & \cos(q_1) * (0.4 * \cos(q_2) + 0.3 * (\cos(q_2 + q_3) + \cos\,(q_2 + q_3 + q_4)) \\ \sin(q_1) * \cos(q_2 + q_3 + q_4) & -\sin(q1) * \sin(q_2 + q_3 + q_4) & -\cos q_1 & \sin(q_1) * (0.4 * \cos(q_2) + 0.3 * (\cos(q_2 + q_3) + \cos\,(q_2 + q_3 + q_4)) \\ \sin(q_2 + q_3 + q_4) & \cos(q_2 + q_3 + q_4) & 0 & 0.4 * \sin(q_2) + 0.3 * (\sin(q_2 + q_3) + \sin(q_2 + q_3 + q_4)) + 0.8 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

Matriz Jacobiana

```python
from sympy import symbols, cos, sin, pi, Matrix, simplify


q1, q2, q3, q4 = symbols('q1 q2 q3 q4')
L1, L2, L3, L4= symbols('L1 L2 L3 L4')

def dh_matrix(theta, d, a, alpha):
    return Matrix([
        [cos(theta), -sin(theta)*cos(alpha), sin(theta)*sin(alpha), a*cos(theta)],
        [sin(theta), cos(theta)*cos(alpha), -cos(theta)*sin(alpha), a*sin(theta)],
        [0,          sin(alpha),             cos(alpha),            d],
        [0,          0,                      0,                     1]
    ])

T01 = dh_matrix(q1, 0.8, 0, pi/2)
T12 = dh_matrix(q2, 0, 0.4,  0)
T23 = dh_matrix(q3, 0, 0.3, 0)
T34 = dh_matrix(q4, 0, 0.3, 0)

T02 = simplify(T01 * T12)
T03 = simplify(T02 * T23)
T04 = simplify(T03 * T34)

O0 = Matrix([0, 0, 0])
O1 = T01[:3, 3]
O2 = T02[:3, 3]
O3 = T03[:3, 3]
O4 = T04[:3, 3]

Z0 = Matrix([0, 0, 1])
Z1 = T01[:3, 2]
Z2 = T02[:3, 2]
Z3 = T03[:3, 2]

Jv1 = Z0.cross(O4 - O0)
Jv2 = Z1.cross(O4 - O1)
Jv3 = Z2.cross(O4 - O2)
Jv4 = Z3.cross(O4 - O3)

Jw1 = Z0
Jw2 = Z1
Jw3 = Z2
Jw4 = Z3

J = simplify(Matrix.hstack(
    Jv1.row_join(Jv2).row_join(Jv3).row_join(Jv4),
    Jw1.row_join(Jw2).row_join(Jw3).row_join(Jw4)
).reshape(6, 4))

J
```

$$\left[\begin{matrix} -\left(0.4\cos(q_2) + 0.3\cos(q_2+q_3) + 0.3\cos(q_2+q_3+q_4)\right)\sin(q_1) & -\left(0.4\sin(q_2) + 0.3\sin(q_2+q_3) + 0.3\sin(q_2+q_3+q_4)\right)\cos(q_1) & -0.3\left(\sin(q_2+q_3) + \sin(q_2+q_3+q_4)\right)\cos(q_1) & -0.3\sin(q_2+q_3+q_4)\cos(q_1) \\ 0 & \sin(q_1) & \sin(q_1) & \sin(q_1) \\ \left(0.4\cos(q_2) + 0.3\cos(q_2+q_3) + 0.3\cos(q_2+q_3+q_4)\right)\cos(q_1) & -\left(0.4\sin(q_2) + 0.3\sin(q_2+q_3) + 0.3\sin(q_2+q_3+q_4)\right)\sin(q_1) & -0.3\left(\sin(q_2+q_3) + \sin(q_2+q_3+q_4)\right)\sin(q_1) & -0.3\sin(q_1)\sin(q_2+q_3+q_4) \\ 0 & -\cos(q_1) & -\cos(q_1) & -\cos(q_1) \\ 0 & 0.4\cos(q_2) + 0.3\cos(q_2+q_3) + 0.3\cos(q_2+q_3+q_4) & 0.3\cos(q_2+q_3) + 0.3\cos(q_2+q_3+q_4) & 0.3\cos(q_2+q_3+q_4) \\ 1 & 0 & 0 & 0 \end{matrix}\right]$$

https://colab.research.google.com/drive/1dPzrUcg4UyTE9zQjwAWS6w0IhSkZZkIK#scrollTo=JGLi4_sYZsvF