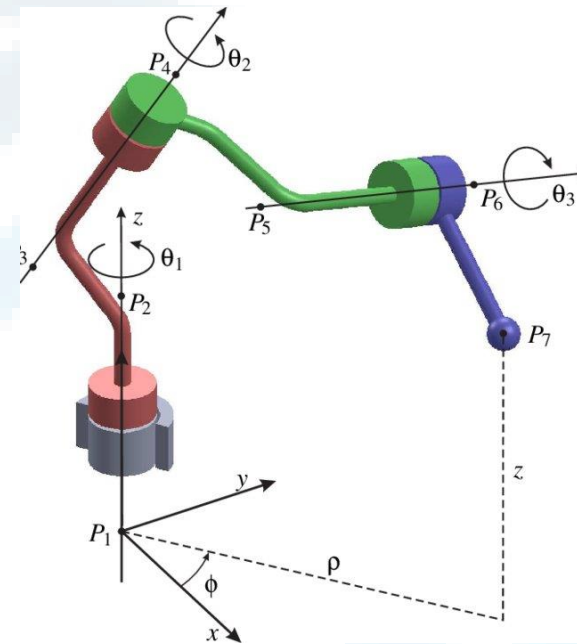


Kinematic models

Direct and inverse kinematic models

Actual & Generalized Parameters

- Actual parameters of a serial robot are the coordinates of its end-effector
- Generalized parameters are the DH variables

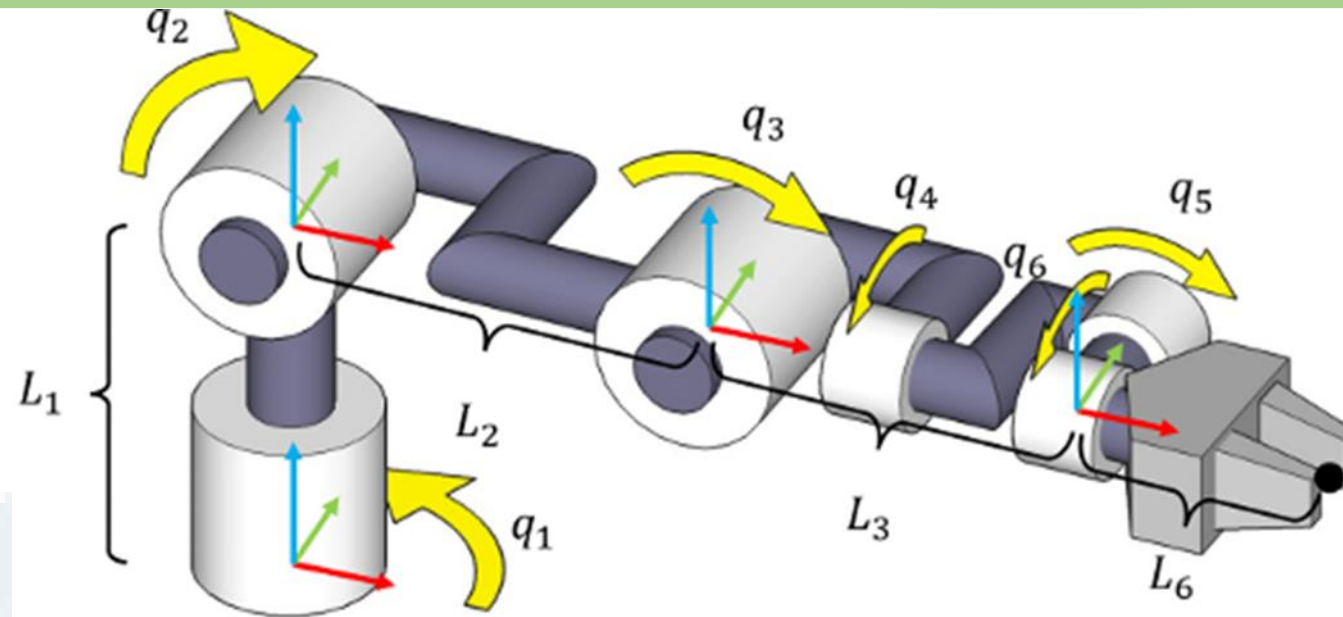


Serial Robot Kinematic Analysis

Robot Presentation

DH Matrices

DKM & IKM



Direct and inverse kinematic models

DKM

- Find **Actual** parameters in fonction of **Generalized** parameters

$$\{x, y, z, r_x, r_y, r_z\} = f(\theta_i, d_i)$$

$$i = 1, 2, \dots, n$$

IKM

- Find **Generalized** parameters in fonction of **Actual** parameters

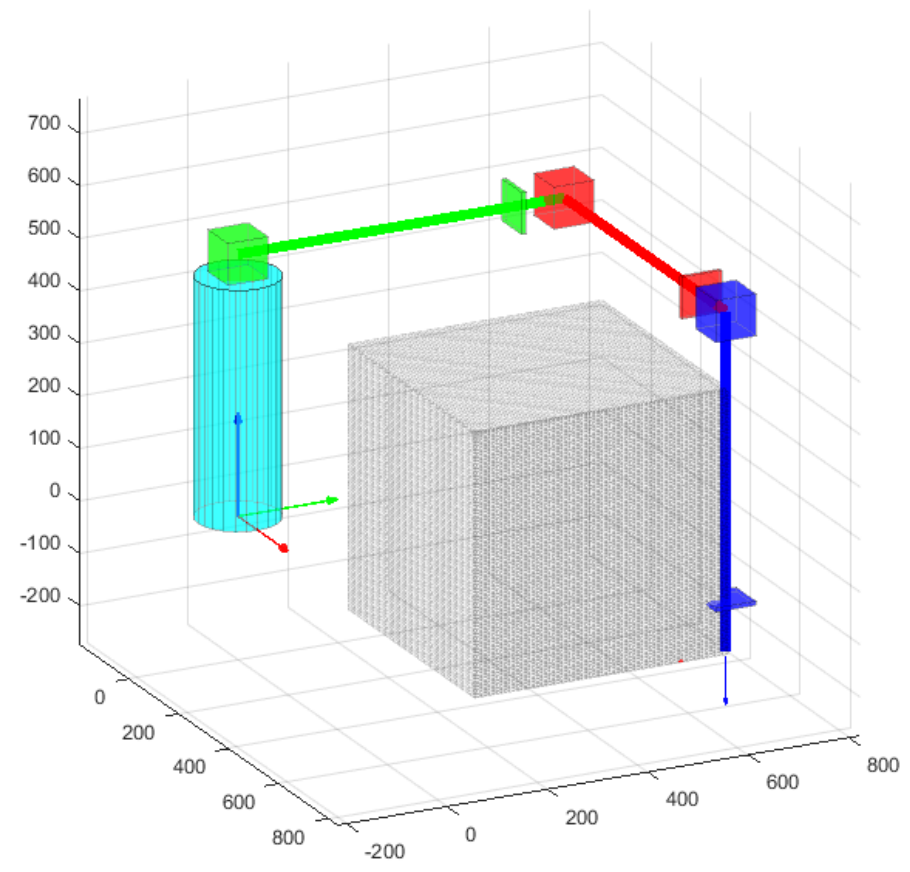
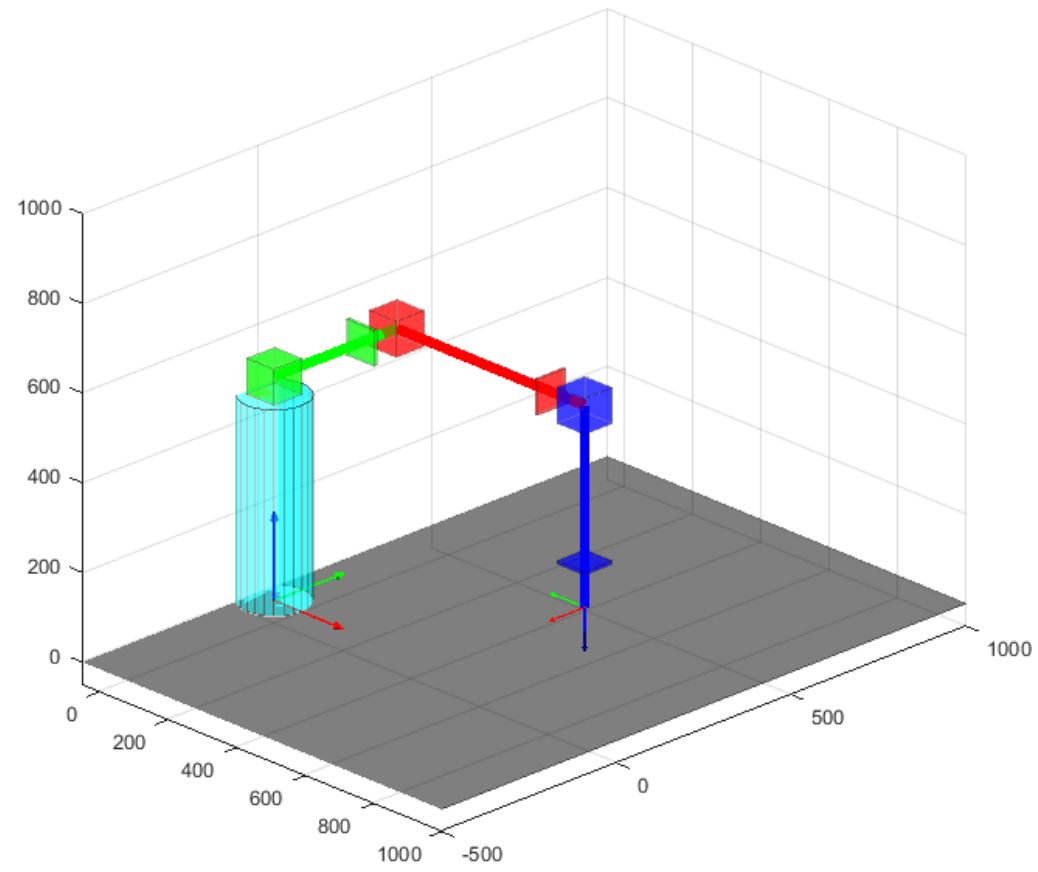
$$\{\theta_i, d_i\} = f(x, y, z, r_x, r_y, r_z)$$

$$i = 1, 2, \dots, n$$

Direct Kinematic Model

Unique solution

Example 1: Cartesian Robot



Find the position and the orientation of the end effector....

When:

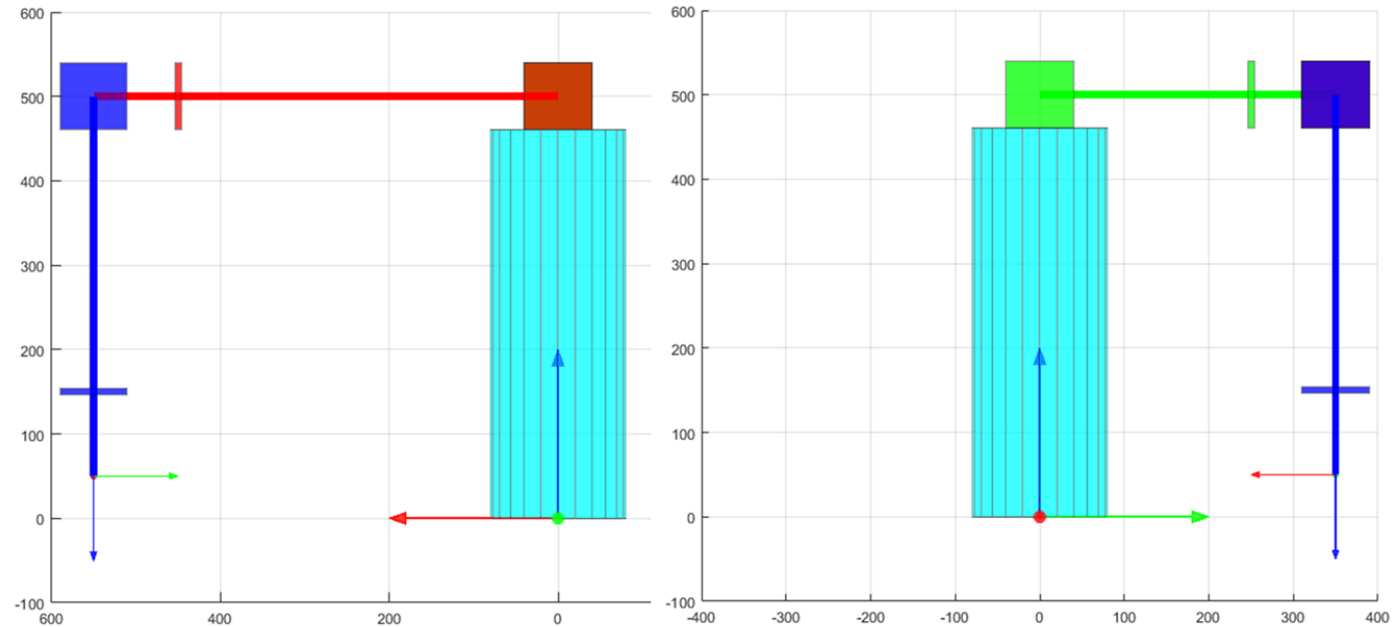
$$\begin{aligned}d_1 &= 200 \\d_2 &= 400 \\d_3 &= 300\end{aligned}$$

If You Know the fixed distances:

$$\begin{aligned}L_0 &= 500 \\L_1 &= 150 \\L_2 &= 150 \\L_3 &= 150\end{aligned}$$

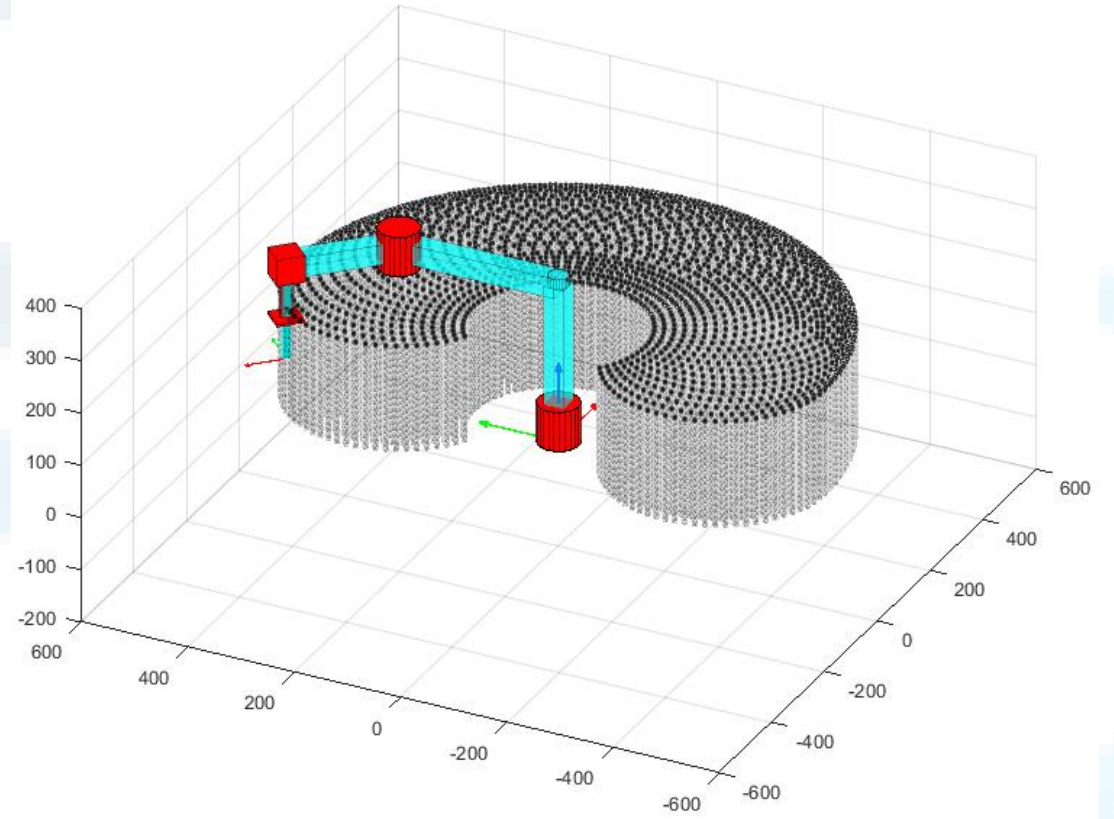
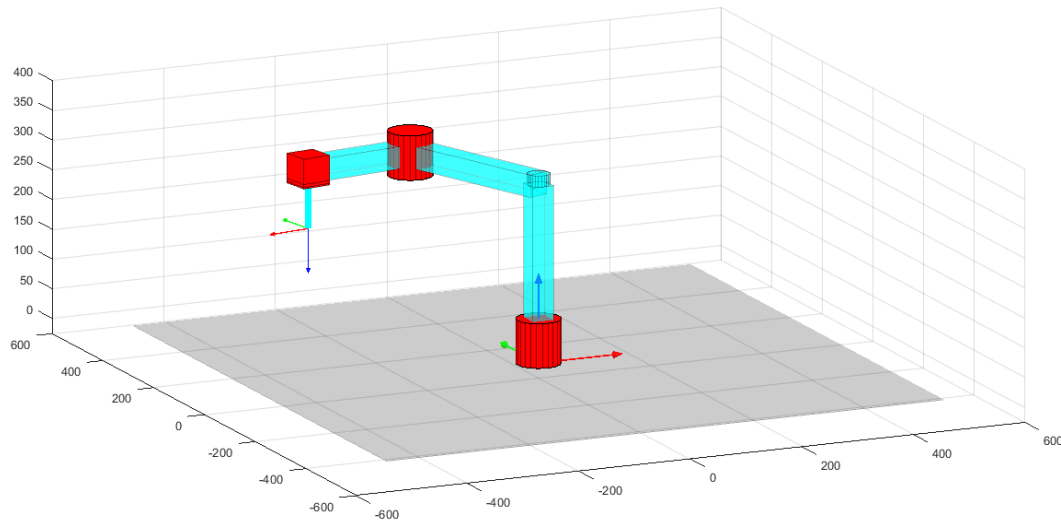
$$TGE = \begin{bmatrix} 0, & -1, & 0, & L_2 + d_2 \\ -1, & 0, & 0, & L_1 + d_1 \\ 0, & 0, & -1, & L_0 - L_3 - d_3 \\ 0, & 0, & 0, & 1 \end{bmatrix}$$

Solution



	Position	RPY_Angels	RPY_Orientation	Euler_Angels	Euler_Orientation
Ex	550	Alfa	-1.5708	Psi	0
Ey	350	Beta	0	Theta	0
Ez	50	Gamma	3.1416	Phi	0
IsOk	1	IsOk	1	IsOk	0

Example 2: SCARA Robot



Find the position and the orientation of the end effector....

When:

$$\theta_1 = \pi/3$$

$$\theta_2 = \pi/6$$

$$d_3 = 100$$

If You Know the fixed distances:

$$Base = 80$$

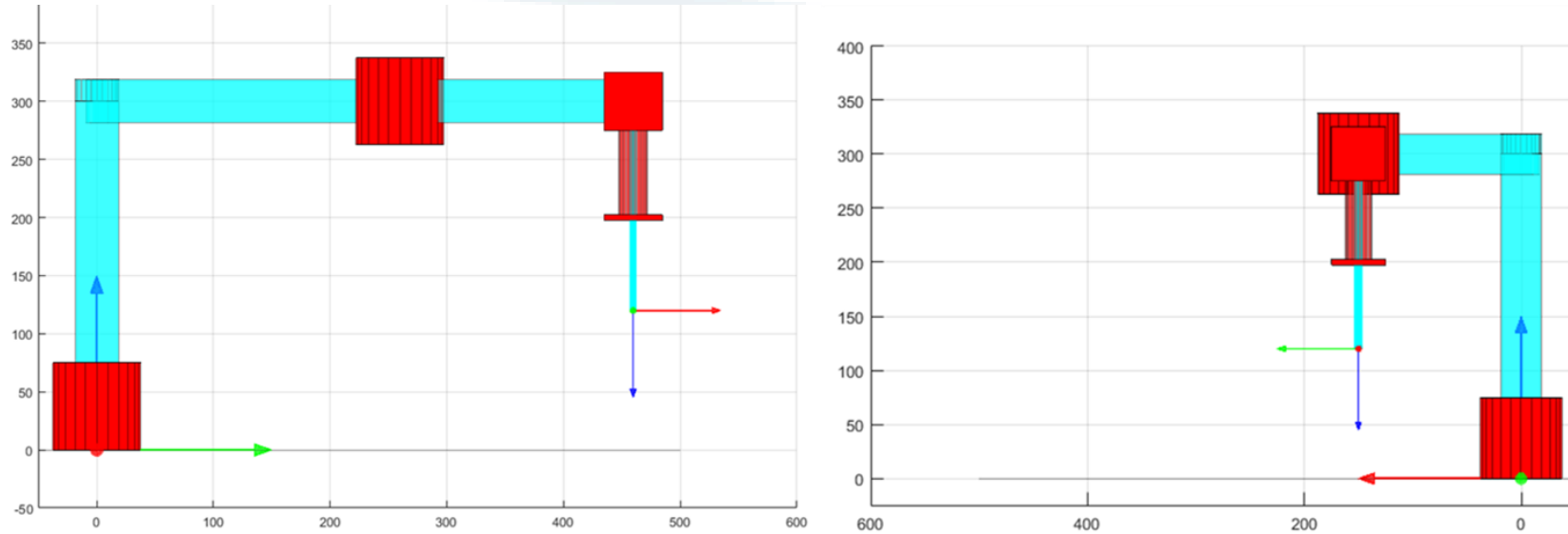
$$L_1 = 300$$

$$L_2 = 300$$

$$L_3 = 200$$

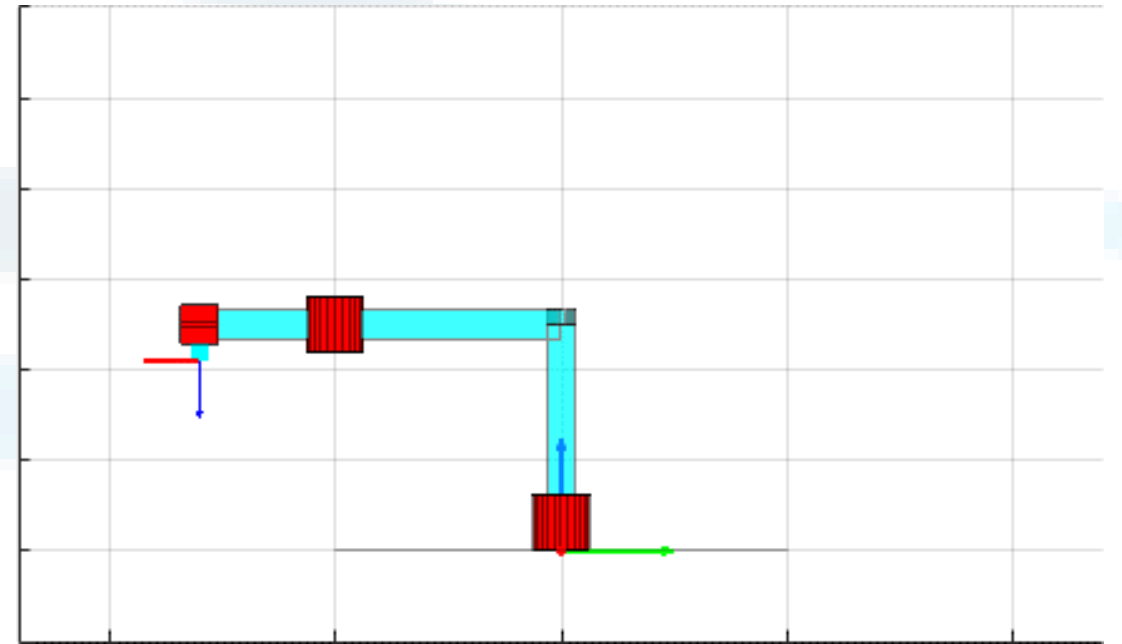
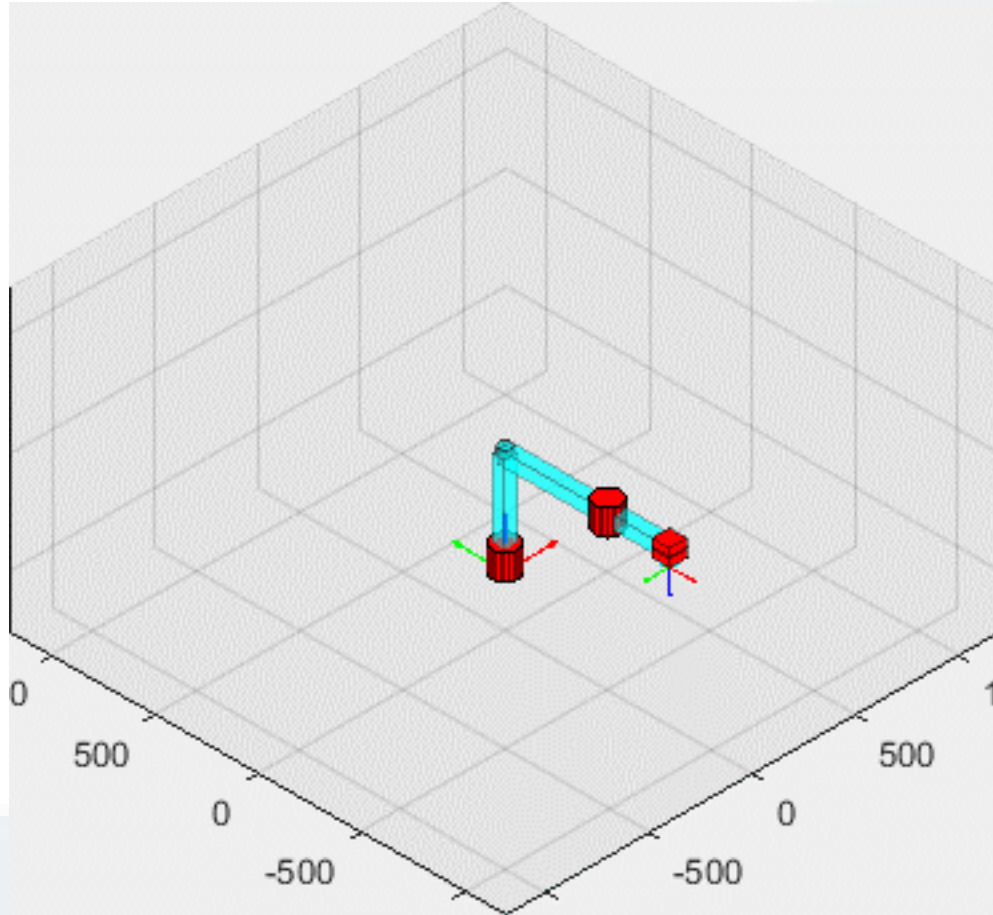
$$T_{03} = \begin{bmatrix} C12, & S12, & 0, & C1*L2 + C12*L3 \\ S12, & -C12, & 0, & L2*S1 + L3*S12 \\ 0, & 0, & -1, & L1 - Base - d3 \\ 0, & 0, & 0, & 1 \end{bmatrix}$$

Solution

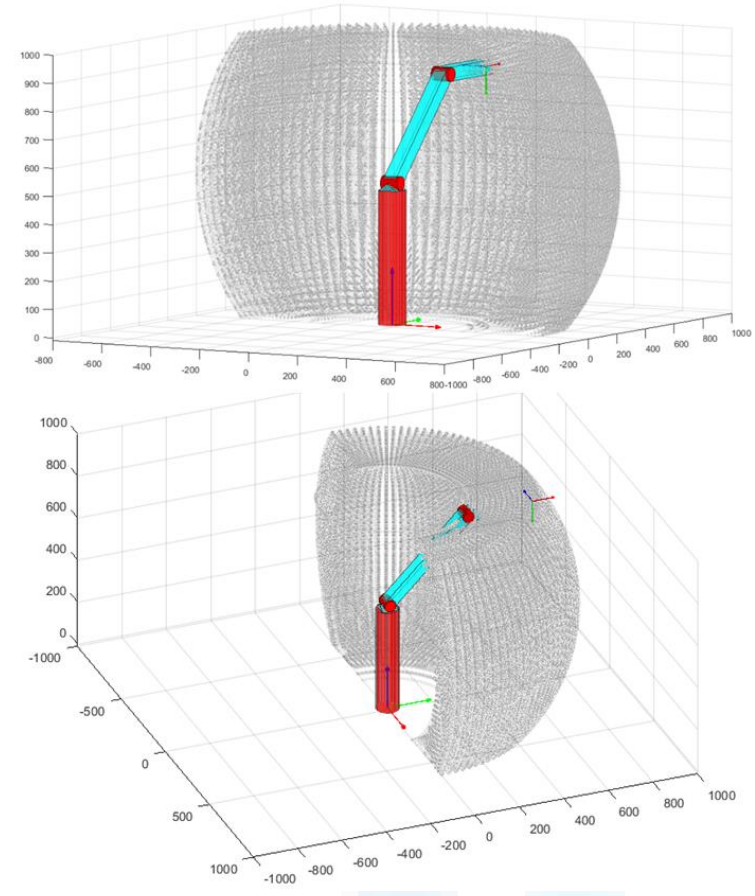
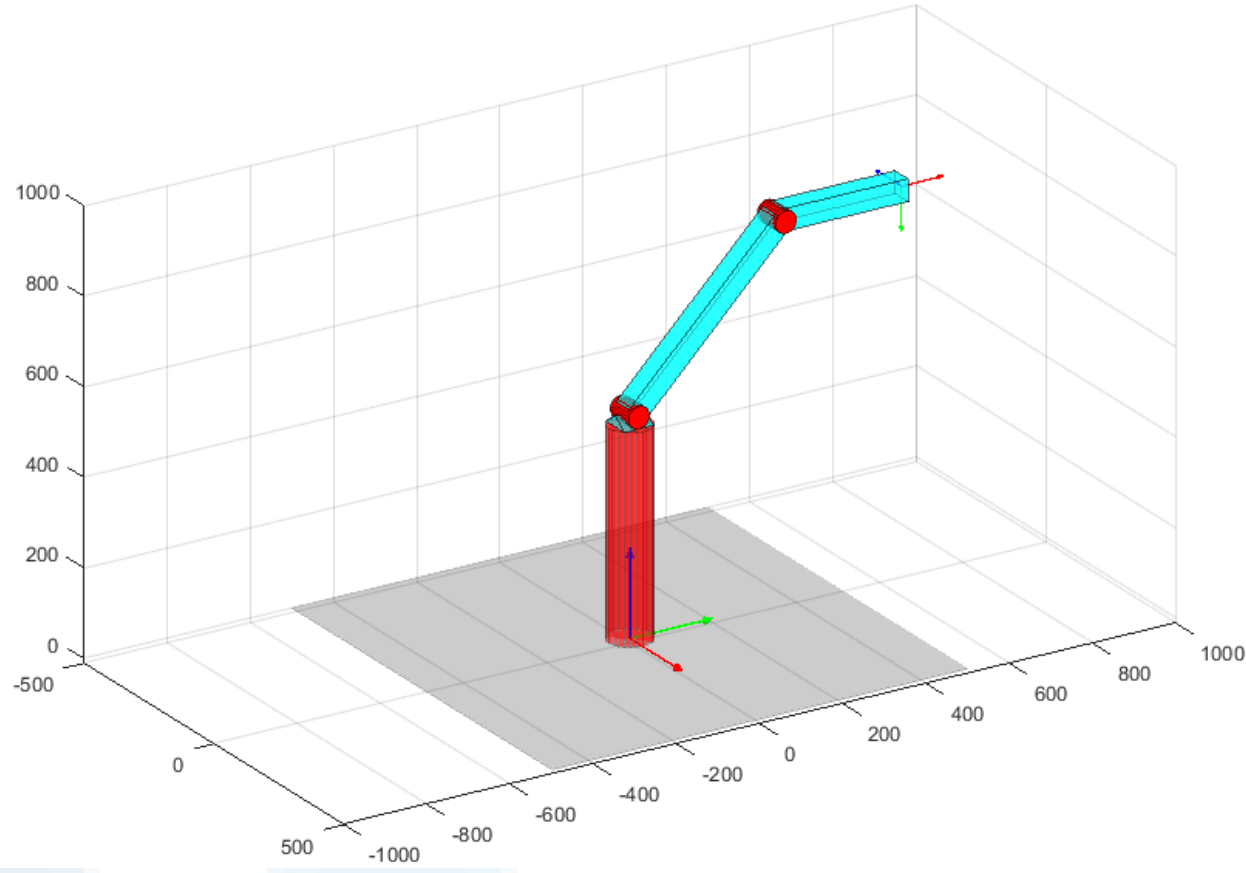


	Position	RPY_Angels	RPY_Orientation	Euler_Angels	Euler_Orientation
Ex	150	Alfa	1.5708	Psi	0
Ey	459.81	Beta	0	Theta	0
Ez	120	Gamma	3.1416	Phi	0
IsOk	1	IsOk	1	IsOk	0

Illustration



Example 3: Elbow Robot



Find the position and the orientation of the end effector....

When:

$$\theta_1 = \pi/2$$

$$\theta_2 = \pi/6$$

$$\theta_3 = -\pi/4$$

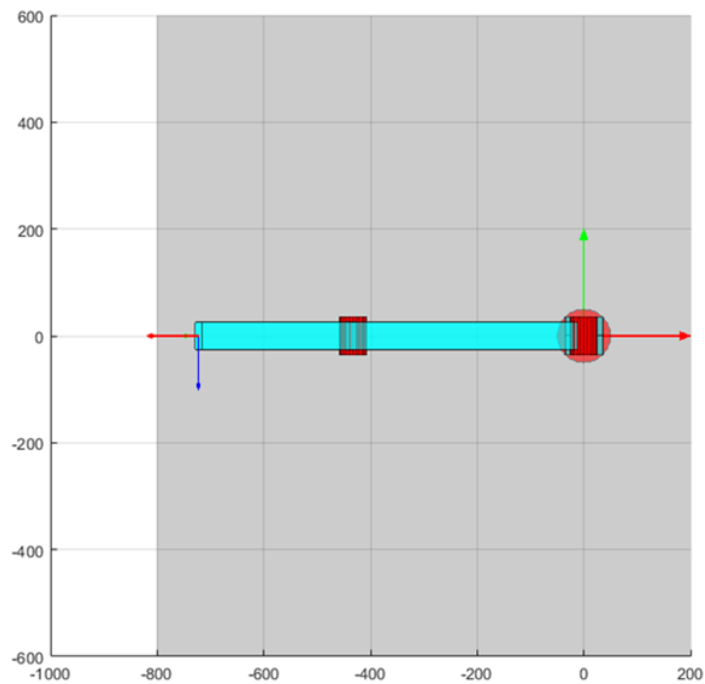
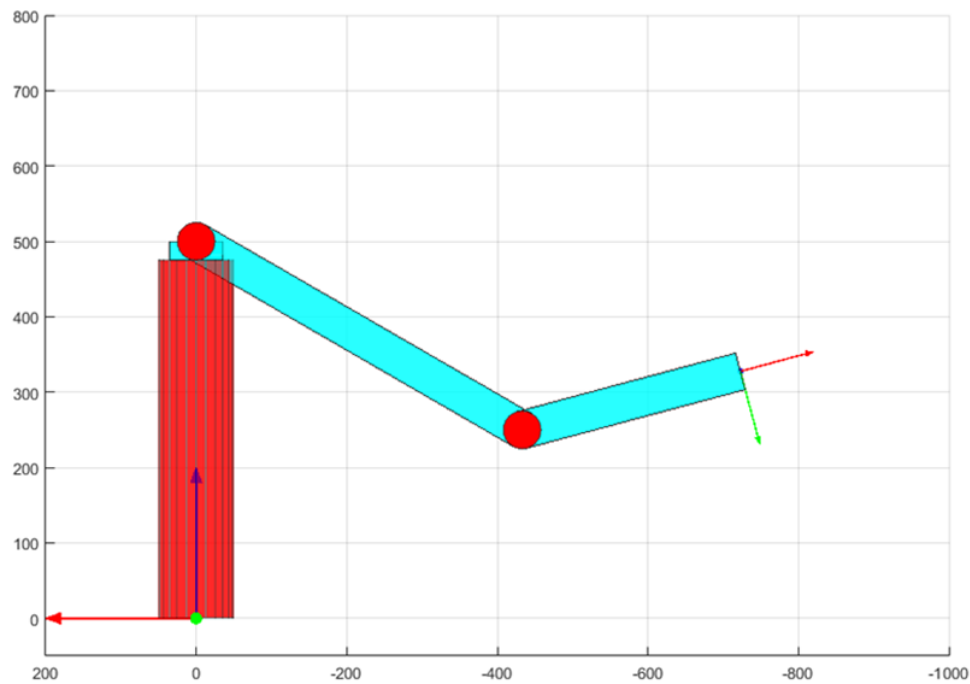
If You Know the fixed distances:

$$L_1 = 500$$

$$L_2 = 500$$

$$L_3 = 300$$

$$T_{03} = \begin{bmatrix} -C_{23}S_1 & S_1S_{23} & -C_1 & -S_1(C_2L_2 + C_{23}L_3) \\ C_1C_{23} & -C_1S_{23} & -S_1 & C_1(C_2L_2 + C_{23}L_3) \\ -S_{23} & -C_{23} & 0 & L_1 - L_2S_2 - L_3S_{23} \\ 0 & 0 & 0 & 1 \end{bmatrix}$$



	Position	RPY_Angels	RPY_Orientation	Euler_Angels	Euler_Orientation
Ex	-722.79	Alfa	3.1416	Psi	-1.2246e-16
Ey	7.7963e-14	Beta	-0.2618	Theta	1.5708
Ez	327.65	Gamma	-1.5708	Phi	2.8798
IsOk	1	IsOk	1	IsOk	1

Thanks

These examples must be re-done home, and understand the different types of robots.