

# Chapter-3

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## 1 - Link-Connection Description

A frame is defined to attach links, which is named by number according to the attached links

### Link Parameters

#### Chains

- prismatic joint:  $d_i$
- rotation joint:  $\theta_i$

#### Frames

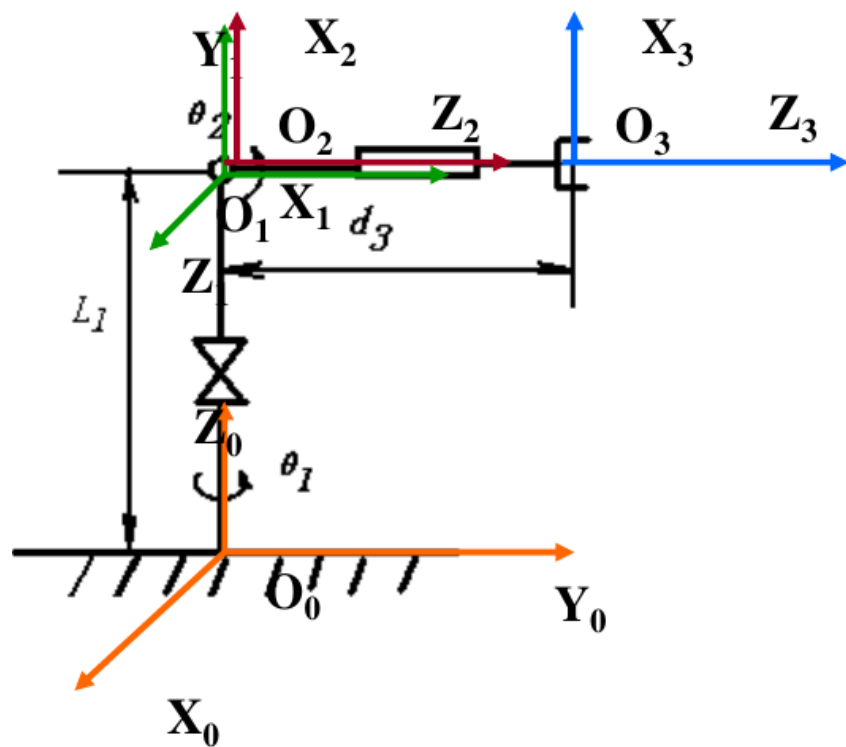
- $\alpha_i$ : the angle from  $\hat{Z}_i$  to  $\hat{Z}_{i+1}$  measured about  $\hat{X}_i$
- $a_i$ : the distance from  $\hat{Z}_i$  to  $\hat{Z}_{i+1}$  measured along  $\hat{X}_i$
- $d_i$ : the distance from  $\hat{X}_{i-1}$  to  $\hat{X}_i$  measured along  $\hat{Z}_i$
- $\theta_i$ : the angle from  $\hat{X}_{i-1}$  to  $\hat{X}_i$  measured about  $\hat{Z}_i$

and the transformation matrix becomes

$$A_i^{i-1} = \begin{bmatrix} \cos \theta_i & -\cos \alpha_i \sin \theta_i & \sin \alpha_i \sin \theta_i & a_i \cos \theta_i \\ \sin \theta_i & \cos \alpha_i \cos \theta_i & -\sin \alpha_i \cos \theta_i & a_i \sin \theta_i \\ 0 & \sin \alpha_i & \cos \alpha_i & d_i \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

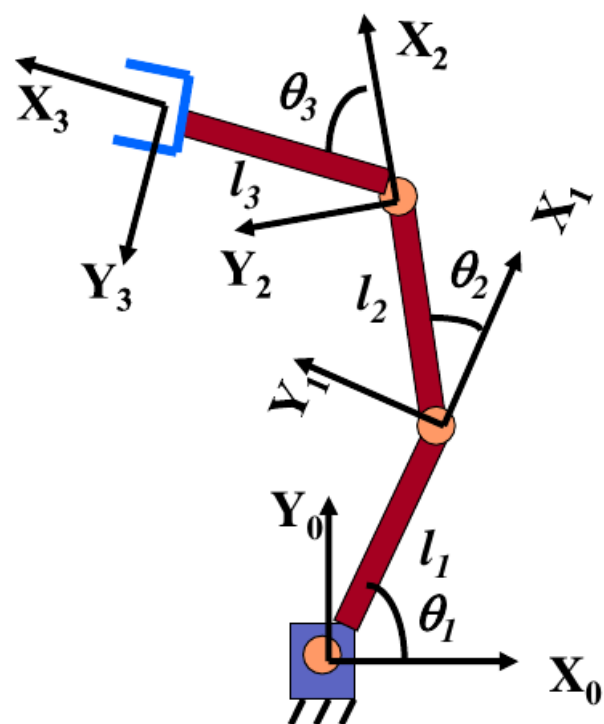
## 2 - Examples

### EX-1



| D-H table  |            |            |       |
|------------|------------|------------|-------|
| $A_i$      | $A_1$      | $A_2$      | $A_3$ |
| $a_i$      | 0          | 0          | 0     |
| $\alpha_i$ | $90^\circ$ | $90^\circ$ | 0     |
| $d_i$      | $L_1$      | 0          | $d_3$ |
| $\theta_i$ | $\theta_1$ | $\theta_2$ | 0     |

### EX-2

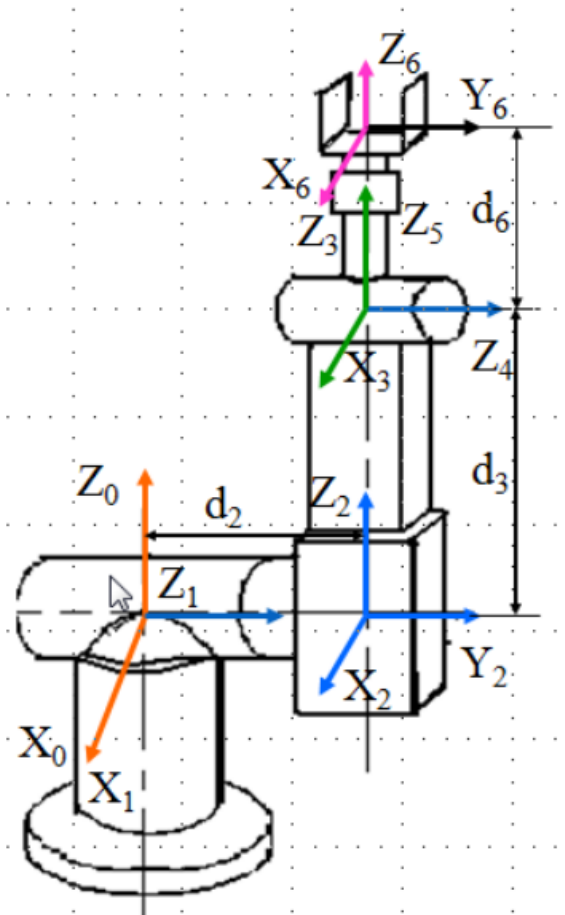


| D-H table |            |       |       |            |
|-----------|------------|-------|-------|------------|
| Joint $i$ | $\alpha_i$ | $a_i$ | $d_i$ | $\theta_i$ |
| 1         | 0          | $l_1$ | 0     | $\theta_1$ |
| 2         | 0          | $l_2$ | 0     | $\theta_2$ |
| 3         | 0          | $l_3$ | 0     | $\theta_3$ |

### EX-3

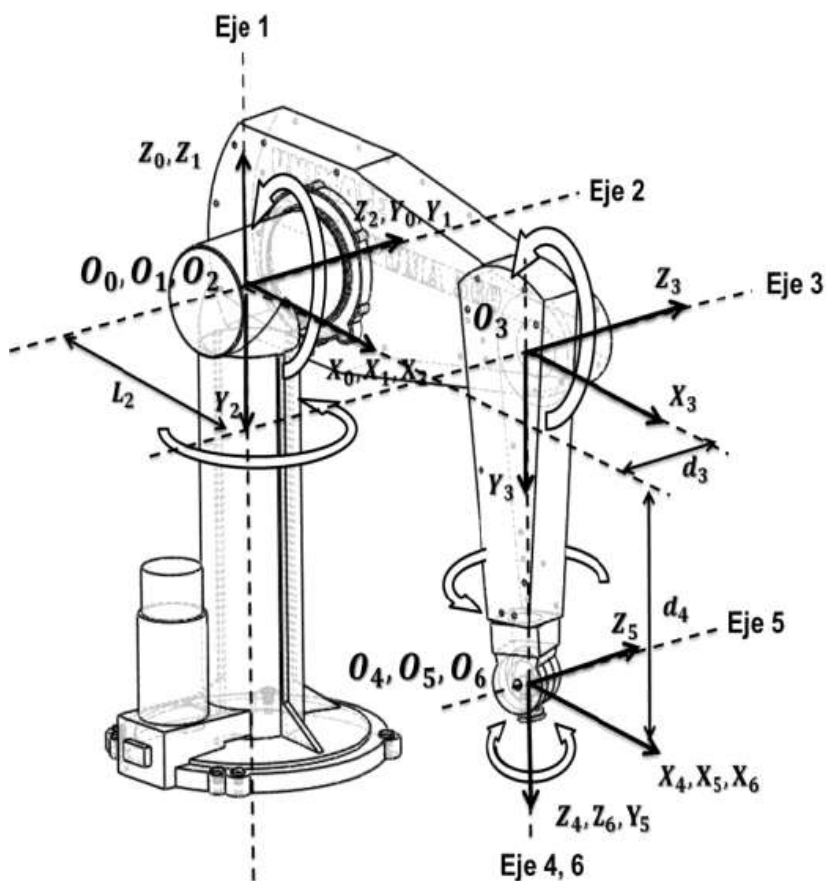
## Example: Stanford

| Joint $i$ | $\alpha_i$  | $a_i$ | $d_i$ | $\theta_i$ | Joint $V$  |
|-----------|-------------|-------|-------|------------|------------|
| 1         | $-90^\circ$ | 0     | 0     | $\theta_1$ | $\theta_1$ |
| 2         | $90^\circ$  | 0     | $d_2$ | $\theta_2$ | $\theta_2$ |
| 3         | 0           | 0     | $d_3$ | 0          | $d_3$      |
| 4         | $-90^\circ$ | 0     | 0     | $\theta_4$ | $\theta_4$ |
| 5         | $90^\circ$  | 0     | 0     | $\theta_5$ | $\theta_5$ |
| 6         | 0           | 0     | $d_6$ | $\theta_6$ | $\theta_6$ |



## EX-4

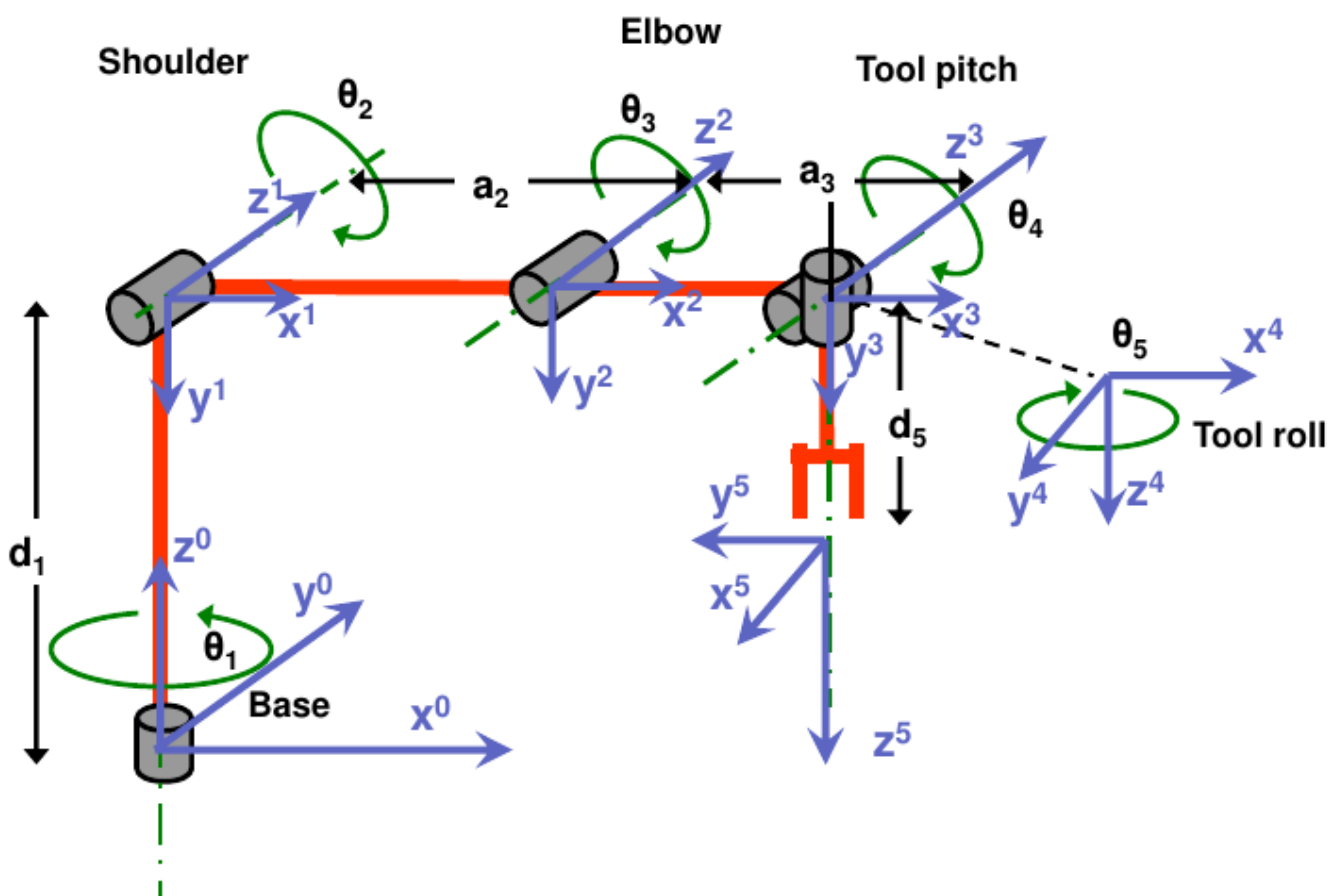
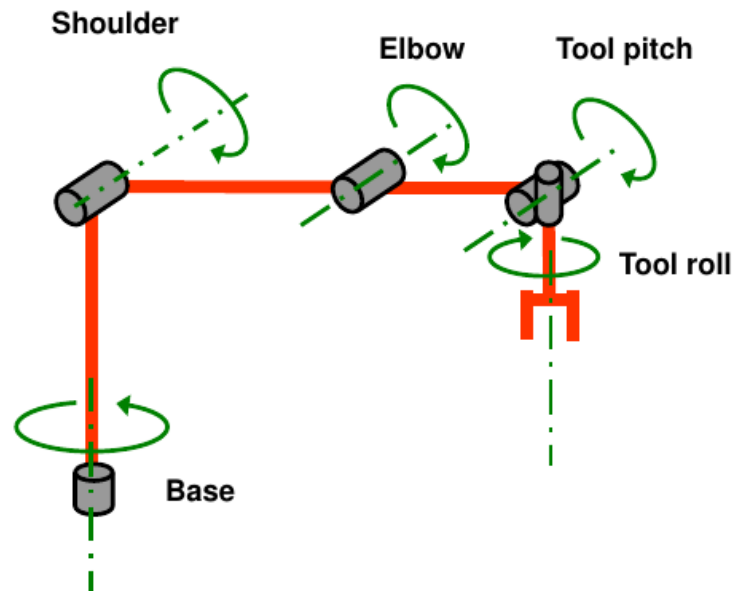
### D-H



| $i$ | $\alpha_i - 1$ | $a_i - 1$ | $d_i$ | $\theta_i$ |
|-----|----------------|-----------|-------|------------|
| 1   | 0              | 0         | 0     | $\theta_1$ |
| 2   | $-90^\circ$    | 0         | 0     | $\theta_2$ |
| 3   | 0              | $a_2$     | $d_3$ | $\theta_3$ |
| 4   | $-90^\circ$    | $a_3$     | $d_4$ | $\theta_4$ |
| 5   | $90^\circ$     | 0         | 0     | $\theta_5$ |
| 6   | $-90^\circ$    | 0         | 0     | $\theta_6$ |

## EX-5

Assign frames on each joint and list the DH table



| Axis | $\theta$   | d     | a     | $\alpha$    | Home |
|------|------------|-------|-------|-------------|------|
| 1    | $\theta_1$ | $d_1$ | 0     | $-90^\circ$ | 0    |
| 2    | $\theta_2$ | 0     | $a_2$ | 0           | 0    |
| 3    | $\theta_3$ | 0     | $a_3$ | 0           | 0    |
| 4    | $\theta_4$ | 0     | 0     | $-90^\circ$ | 0    |
| 5    | $\theta_5$ | $d_5$ | 0     | 0           | 90   |