

a-)

	$\theta_i$	$d_i$	$a_i$	$\alpha_i$
1	0	1	0	0
2	0	$5.35+d_1$	0	0
3	$\theta_2$	0	4	0

$$A_1 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 \end{bmatrix}, \quad A_2 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 5.35+d_1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A_3 = \begin{bmatrix} \cos \theta_2 & -\sin \theta_2 & 0 & 4 \cos \theta_2 \\ \sin \theta_2 & \cos \theta_2 & 0 & 4 \sin \theta_2 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}, \quad A = A_1 A_2 A_3 = \begin{bmatrix} \cos \theta_2 & -\sin \theta_2 & 0 & 4 \cos \theta_2 \\ \sin \theta_2 & \cos \theta_2 & 0 & 4 \sin \theta_2 \\ 0 & 0 & 1 & 6.35+d_1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Configuration  $S_1 = C_P \times C_R \Rightarrow$

$$C_P \Rightarrow 0 \leq d_1 \leq 4$$

$$C_R \Rightarrow -\pi \leq \theta_2 \leq \pi$$

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$$\text{Workspace} = \left\{ \begin{bmatrix} 0 \\ 0 \\ 6.35 \end{bmatrix} + \begin{bmatrix} 4 \cos \theta_2 \\ 4 \sin \theta_2 \\ d_1 \end{bmatrix}, \quad \begin{matrix} \theta_2 \in C_R \\ d_1 \in C_P \end{matrix} \right\}$$

b-)First set:

b7-)

Set 2 = (1.3, -1)

$$A1 = \begin{bmatrix} 0.54 & 0.84 & 0 & 2.16 \\ -0.84 & 0.54 & 0 & -3.36 \\ 0 & 0 & 1 & 7.65 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

```
[100%] Built target robot_model_node
goksel@goksel-N551VW:~/GitHub/IntroToRobotics/myrobotws$ source devel/setup.bash
goksel@goksel-N551VW:~/GitHub/IntroToRobotics/myrobotws$ rosrn manipulator_core robot_model_node
[ INFO] [1608429101.556560475]: Loading robot model 'pr_robot'...
[ INFO] [1608429101.600766219]: Model frame: base_link
[ INFO] [1608429101.600847321]: Joint joint1_base_link_to_link1: 0.000000
[ INFO] [1608429101.600875078]: Joint joint2_link1_to_link2: 0.000000
[ INFO] [1608429101.600910593]: Current state is not valid
[ INFO] [1608429101.600939634]: Current state is valid
[ INFO] [1608429101.600948674]: First Set of Joints :

[ INFO] [1608429101.600973574]: d1      : joint1_base_link_to_link1      : 1.300000
[ INFO] [1608429101.601004477]: theta 2 : joint2_link1_to_link2 : -1.000000
[ INFO] [1608429101.601052194]: Translation:
  2.16121
-3.36588
  7.65

[ INFO] [1608429101.601198393]: Rotation:
  0.540302  0.841471      0
-0.841471  0.540302      0
      0      0          1
```

Second Set:

Set 2 = (3.5, 3.1)

$$A2 = \begin{bmatrix} -0.999 & -0.042 & 0 & -3.996 \\ 0.042 & -0.999 & 0 & 0.764 \\ 0 & 0 & 1 & 9.85 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

## Second Set of Joints :

```
[ INFO] [1608429101.601507787]: d1      : joint1_base_link_to_link1      : 3.500000
[ INFO] [1608429101.601518764]: theta 2 : joint2_link1_to_link2 : 3.100000
[ INFO] [1608429101.601563548]: Translation:
-3.99654
0.166323
 9.85

[ INFO] [1608429101.601700568]: Rotation:
-0.999135 -0.0415807      0
 0.0415807 -0.999135      0
          0          0      1
```

b2-) set 1//  $\rightarrow$  dist multiplied by 4th column

$$O^0 = A^1 \cdot O^2 = [2.16, -3.36, 7.65, 1]^T$$

$$\underline{O^0 = [2.16, -3.36, 7.65]^T}$$

set 2//

$$O^0 = A^2 \cdot O^2 = [-3.996, 0.166, 9.85, 1]^T$$

$$O^0 = [-3.996, 0.166, 9.85]^T$$

Set 1:

```
[ INFO] [1608429101.601233815]: FOR SET 1
Representing The Origin of Frame 2 in the Frame 0:
[ INFO] [1608429101.601283573]:
 2.16121
-3.36588
 7.65
```

Set 2:

```
[ INFO] [1608429101.601721030]: FOR SET 2
Representing The Origin of Frame 2 in the Frame 0:
[ INFO] [1608429101.601742072]:
-3.99654
0.166323
9.85
```

b) -)

$$O^0 = A(d_1, \theta_2) O^2 = \begin{bmatrix} 4 \cos \theta \\ 4 \sin \theta \\ 0.35 + d^1 \\ 1 \end{bmatrix}$$

for set 2  $\rightarrow 2.16 = 6 \cdot \cos \theta$   $\cos \theta = 0.54$   
 $\theta = 1 \text{ rad}$   
 $\rightarrow 7.65 = 6.35 + d_1$   $d_1 = 1.3$

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for set 2  $\rightarrow 0.164 = h \sin \theta$   $\sin \theta = 0.041$   
 $\rightarrow 9.85 = 6.35 + d_i$   $\theta = 3.7 \text{ rad}$   
 $d_i = 3.5$

Set 1:

```
[ INFO] [1608429101.601455091]: Joint joint1_base_link_to_link1: 1.300000
[ INFO] [1608429101.601467487]: Joint joint2_link1_to_link2: -1.000000
[ INFO] [1608429101.601477203]:
```

Set 2:

```
[ INFO] [1608429101.601767061]: Joint joint1_base_link_to_link1: 3.500000
[ INFO] [1608429101.601778011]: Joint joint2_link1_to_link2: 3.100000
[ INFO] [1608429101.601790898]: IK finished
```

64-) When my robot goes from point set 1 to set 2, It is like it taking some weights and turn then place them in a higher place. This robot can be used in industrial companies.