

3P Robot

Other name - Three Prismatic joint Robot

Dof - 3

Denavit Hartenberg (DH) Parameter

T_i = Minimum number of Parameters to describe forward kinematics

= Rot_{z, θ_i} , Trans_{z, d_i} , Trans_{x, a_i} ,
Rot_{x, α_i}

$$= \begin{bmatrix} \cos \theta_i & -\sin \theta_i & 0 & 0 \\ \sin \theta_i & \cos \theta_i & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & d_i \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 & 0 & a_i \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos \alpha_i & -\sin \alpha_i & 0 \\ 0 & \sin \alpha_i & \cos \alpha_i & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

where,

a_i - link length

α_i - link twist

d_i - link offset

θ_i - Joint angle

Final DH matrix

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

Forward kinematics

Joint 1

$$\theta = 90^\circ \quad a_i = 0 \text{ m} \quad \alpha_i = 90^\circ \quad d_i = 0.3 \text{ m}$$

$$T_1 = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0.3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Here,

$$\cos 90^\circ = 0$$

$$\sin 90^\circ = 1$$

Joint 2

$$\theta = -90^\circ \quad a_1 = 0.15 \text{ m} \quad \alpha = 90^\circ \quad d_1 = 0.2 \text{ m}$$

$$T_2 = \begin{bmatrix} 0 & 0 & -1 & 0 \\ -1 & 0 & 0 & -0.15 \\ 0 & 1 & 0 & 0.2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Here,

$$\cos(-90^\circ) = 0$$

$$\sin(-90^\circ) = -1$$

$$\cos(90^\circ) = 0$$

$$\sin(90^\circ) = 1$$

Joint 3

$$\theta = 0^\circ \quad a_1 = 0.15 \text{ m} \quad \alpha = 90^\circ \quad d_1 = 0.2 \text{ m}$$

$$T_3 = \begin{bmatrix} 1 & 0 & 0 & 0.15 \\ 0 & 0 & -1 & 0 \\ 0 & 1 & 0 & 0.2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Here,

$$\cos 0 = 1$$

$$\sin 0 = 0$$

$$\cos 90 = 0$$

$$\sin 90 = 1$$

$$T = T_1 T_2 T_3$$

$$= \begin{bmatrix} 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0.3 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 & 0 & -1 & 0 \\ -1 & 0 & 0 & -0.15 \\ 0 & 1 & 0 & 0.2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 & 0 & 0.15 \\ 0 & 0 & -1 & 0 \\ 0 & 1 & 0 & 0.2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 0 & 1 & 0 & 0.2 \\ 0 & 0 & -1 & 0 \\ -1 & 0 & 0 & 0.15 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0.15 \\ 0 & 0 & -1 & 0 \\ 0 & 1 & 0 & 0.2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Forward kinematics of 3R robot after set on desired position from origin point

$$= \begin{bmatrix} 0 & 0 & -1 & 0.2 \\ 0 & -1 & 0 & -0.2 \\ -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad \text{--- ①}$$

∴ Thus the above matrix is verified ^{based} on 66 RoboAnalyzer ^{2D} Software

VERIFICATION

RoboAnalyzer

File

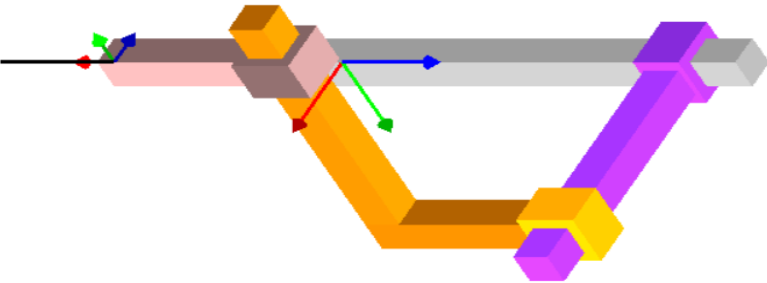
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3D Model

Graph



D-H Parameters

Robot	Joint No	Joint Type	Joint Offset (b) m	Joint Angle (theta) deg	Link Length (a) m	Twist Angle (alpha) deg	Initial Value (UV) deg or m	Final Value (UV) deg or m
Select DOF	1	Pneumatic	Variable	90	0	90	0.1	0.3
Select Robot	2	Pneumatic	Variable	-90	0.15	90	0.1	0.2
3p	3	Pneumatic	Variable	0	0.15	90	0.1	0.2

Visualize DH

Link Config

EE Config

Joint Trajectory

Link3

Base Frame

Update

0

0

0

0

-1

0

0

0

-1

0

0

0

0.2

-0.2

0

1

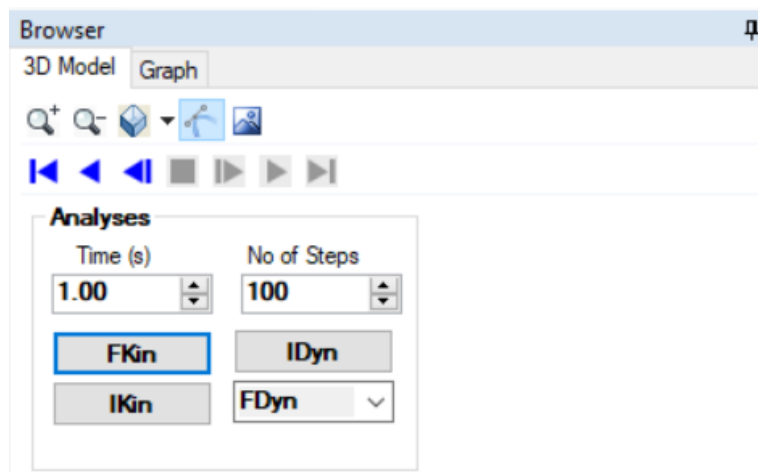
More Robots

OK

PROCEDURE VIDEO FOR ROBOANALYZER [DEMO VIDEO](#)

PROCEDURE

1. Open the RoboAnalyzer software.
2. Select **3** on the **select DOF** dropdown list and also select **3P (3 PRISMATIC JOINT ROBOT)** on the **select robot** dropdown list.
3. Press **FKin** button on the 3D model tab to simulate forward kinematics matrices for the final (or) desired position from origin position (or) point.



4. Then click Link Config tab to select **link 3** and change previous frame to **base frame**. Eventually press the **Update** button to get the **DH matrix** for 3P Robot.
5. Finally, I compared the software DH matrix with an observed DH matrix that I solved.

Inverse kinematics

Joint 1

$$\theta = 90^\circ \quad a_i = 0 \text{ m} \quad \alpha_i = 90^\circ \quad d_i = d_1 \text{ (variable)}$$

$$A_1 = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & d_1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Joint 2

$$\theta = -90^\circ \quad a_i = 0.15 \text{ m} \quad \alpha_i = 90^\circ \quad d_i = d_2 \text{ (variable)}$$

$$A_2 = \begin{bmatrix} 0 & 0 & -1 & 0 \\ -1 & 0 & 0 & 0.15 \\ 0 & 1 & 0 & d_2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Joint 3

$$\theta = 0^\circ \quad a_i = 0.15 \text{ m} \quad \alpha_i = 90^\circ \quad d_i = d_3 \text{ (variable)}$$

$$A_3 = \begin{bmatrix} 1 & 0 & 0 & 0.15 \\ 0 & 0 & -1 & 0 \\ 0 & 1 & 0 & d_3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T = A_1 A_2 A_3$$

$$= \begin{bmatrix} 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & d_1 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 & 0 & -1 & 0 \\ -1 & 0 & 0 & -0.15 \\ 0 & 1 & 0 & d_2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 & 0 & 0.15 \\ 0 & 0 & -1 & 0 \\ 0 & 1 & 0 & d_3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 0 & 1 & 0 & d_2 \\ 0 & 0 & -1 & 0 \\ -1 & 0 & 0 & -0.15 + d_1 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0.15 \\ 0 & 0 & -1 & 0 \\ 0 & 1 & 0 & d_3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 0 & 0 & -1 & d_2 \\ 0 & 0 & 0 & -d_3 \\ -1 & 0 & 0 & (-0.15 - 0.15 + d_1) \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 0 & 0 & -1 & d_2 \\ 0 & 0 & 0 & -d_3 \\ -1 & 0 & 0 & -0.3 d_1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Compare ① & ② matrix to
find d_1, d_2, d_3

$$\text{i) } d_2 = 0.2$$

$$\text{ii) } -d_3 = -0.2$$

$$d_3 = 0.2$$

$$\text{iii) } -0.3 + d_1 = 0$$

$$d_1 = 0.3$$

\therefore Thus above Parameters like d_1, d_2, d_3 are verified based on "RoboAnalyser" software.