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Id: 20205107

Homework #2

1.

$$ {}^{0}_{2}T = \begin{bmatrix} c_1c_2 & -c_1s_2 & s_1 & l_1c_1 \\ s_1c_2 & -s_1s_2 & -c_1 & l_1s_1 \\ s_2 & c_2 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

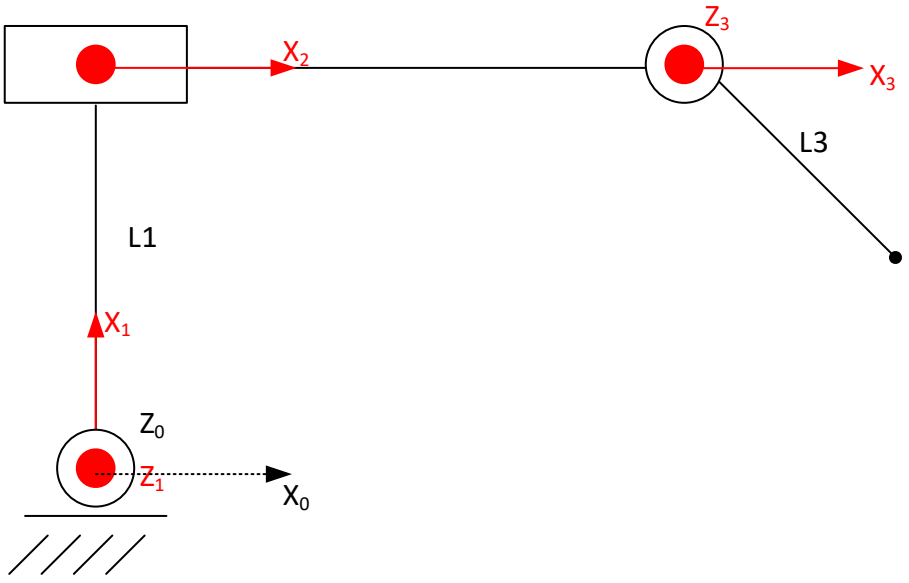
We have

$$ {}^{0}P_{Tip} = {}^{0}_{2}T\,{}^{2}P_{Tip} \text{ with } P_{Tip} = \begin{bmatrix} l_2 \\ 0 \\ 0 \\ 1 \end{bmatrix} $$

$$ {}^{0}P_{Tip} = \begin{bmatrix} c_1c_2 & -c_1s_2 & s_1 & l_1c_1 \\ s_1c_2 & -s_1s_2 & -c_1 & l_1s_1 \\ s_2 & c_2 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} l_2 \\ 0 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} l_2c_1c_2 + l_1c_1 \\ l_2s_1c_2 + l_1s_1 \\ l_2 \\ 1 \end{bmatrix} $$

2.

a)



b)

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i	a_{i-1}	α_{i-1}	d_i	θ_i
1	0	0	0	θ_1+90
2	L1	0	0	0
3	d_2	0	L3	θ_3

c)

$$ {}^{0}_{1}T = \begin{bmatrix} c(\theta_1+90) & -s(\theta_1+90) & 0 & 0 \\ s(\theta_1+90) & c(\theta_1+90) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

$$ {}^{1}_{2}T = \begin{bmatrix} 1 & 0 & 0 & L1 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

$$ {}^{2}_{3}T = \begin{bmatrix} c\theta_3 & -s\theta_3 & 0 & d_2 \\ s\theta_3 & c\theta_3 & 0 & 0 \\ 0 & 0 & 1 & L3 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

$$ {}^{0}_{3}T = {}^{0}_{1}T\,{}^{1}_{2}T\,{}^{2}_{3}T = \begin{bmatrix} c(\theta_1+90)c\theta_3 - s(\theta_1+90)s\theta_3 & -c(\theta_1+90)s\theta_3 - s(\theta_1+90)c\theta_3 & 0 & d_2c(\theta_1+90) + L1c(\theta_1+90) \\ s(\theta_1+90)c\theta_3 + c(\theta_1+90)s\theta_3 & c(\theta_1+90)c\theta_3 - s(\theta_1+90)s\theta_3 & 0 & d_2s(\theta_1+90) + L1s(\theta_1+90) \\ 0 & 0 & 1 & L3 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

3.

$$ {}^{0}P_T = {}^{0}_{6}T\,{}^{6}P_T $$

MATLAB CODE:

```
clc
theta1=45;
theta2=60;
theta3=45;
theta4=60;
theta5=45;
theta6=30;
a2 = 1;
a3 = 0.3;
d3 = 0.5;
d4 = 1;
P6_T= [0;
```

```
       0;
       0.2;
       1];

T0_1 = [cos(theta1), -sin(theta1), 0, 0;
        sin(theta1),  cos(theta1), 0, 0;
                  0,           0, 1, 0;
                  0,           0, 0, 1];

T1_2 = [ cos(theta2), -sin(theta2), 0, 0;
                  0,           0, 1, 0;
        -sin(theta2), -cos(theta2), 0, 0;
                  0,           0, 0, 1];

T2_3 = [cos(theta3), -sin(theta3), 0, a2;
        sin(theta3),  cos(theta3), 0, 0;
                  0,           0, 1, d3;
                  0,           0, 0, 1];

T3_4 = [ cos(theta4), -sin(theta4), 0, a3;
                  0,           0, 1, d4;
        -sin(theta4), -cos(theta4), 0, 0;
                  0,           0, 0, 1];

T4_5 = [ cos(theta5), -sin(theta5),  0, 0;
                  0,           0, -1, 0;
         sin(theta5),  cos(theta5),  0, 0;
                  0,           0,  0, 1];

T5_6 = [ cos(theta6), -sin(theta6), 0, 0;
                  0,           0, 1, 0;
        -sin(theta6), -cos(theta6), 0, 0;
                  0,           0, 0, 1];

T0_6 = T0_1 * T1_2 * T2_3 * T3_4 * T4_5 * T5_6

P0_T = T0_1 * T1_2 * T2_3 * T3_4 * T4_5 * T5_6 * P6_T
```

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Result:

${}^{0}_{6}T$ is

Command Window

```
T0_6 =

    0.8945    0.2256    0.3859   -0.4539
   -0.2954    0.9463    0.1314    0.2166
   -0.3356   -0.2316    0.9131    0.8369
         0         0         0    1.0000
```

${}^{0}P_{T}$ is

Command Window

```
P0_T =

   -0.3767
    0.2429
    1.0196
    1.0000

fx >>
```