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%MATLAB CODE ASSIGNMENT 2 ENPM662
%ANSWER 1
clc
clear all
%writing the code for A matrices
%%declaring the variables and symbols for the matrix multiplication
syms theta1 theta2 theta3 l1 l2 l3 d4 l4
d1=0;
d2=0;
d3=0;
alpha1=0;
alpha2=0;
alpha3=-90;
alpha4=0;
theta4=-90;
%%The general form of the matrices are obtained by multiplying the
%%following

%%first A matrix
Rz_theta1=[cosd(theta1) -sind(theta1) 0 0;sind(theta1) cosd(theta1) 0
0;0 0 1 0;0 0 0 1];
Rx_alpha1=[1 0 0 0;0 cosd(alpha1) -sind(alpha1) 0;0 sind(alpha1)
cosd(alpha1) 0;0 0 0 1];
Tz_d1=[1 0 0 0;0 1 0 0;0 0 1 d1;0 0 0 1];
Tx_a1=[1 0 0 l1;0 1 0 0;0 0 1 0;0 0 0 1];
%%second A matrix
Rz_theta2=[cosd(theta2) -sind(theta2) 0 0;sind(theta2) cosd(theta2) 0
0;0 0 1 0;0 0 0 1];
Rx_alpha2=[1 0 0 0;0 cosd(alpha2) -sind(alpha2) 0;0 sind(alpha2)
cosd(alpha2) 0;0 0 0 1];
Tz_d2=[1 0 0 0;0 1 0 0;0 0 1 d2;0 0 0 1];
Tx_a2=[1 0 0 l2;0 1 0 0;0 0 1 0;0 0 0 1];
%%third A matrix
Rz_theta3=[cosd(theta3) -sind(theta3) 0 0;sind(theta3) cosd(theta3) 0
0;0 0 1 0;0 0 0 1];
Rx_alpha3=[1 0 0 0;0 cosd(alpha3) -sind(alpha3) 0;0 sind(alpha3)
cosd(alpha3) 0;0 0 0 1];
Tz_d3=[1 0 0 0;0 1 0 0;0 0 1 d3;0 0 0 1];
Tx_a3=[1 0 0 l3;0 1 0 0;0 0 1 0;0 0 0 1];
%%fourth A matrix
Rz_theta4=[cosd(theta4) -sind(theta4) 0 0;sind(theta4) cosd(theta4) 0
0;0 0 1 0;0 0 0 1];
Rx_alpha4=[1 0 0 0;0 cosd(alpha4) -sind(alpha4) 0;0 sind(alpha4)
cosd(alpha4) 0;0 0 0 1];
Tz_d4=[1 0 0 0;0 1 0 0;0 0 1 (d4+l4);0 0 0 1];
Tx_a4=[1 0 0 0;0 1 0 0;0 0 1 0;0 0 0 1];
%%Matrix multiplicaiion
A_1=Rz_theta1*Tz_d1*Tx_a1*Rx_alpha1
A_2=Rz_theta2*Tz_d2*Tx_a2*Rx_alpha2
A_3=Rz_theta3*Tz_d3*Tx_a3*Rx_alpha3
A_4=Rz_theta4*Tz_d4*Tx_a4*Rx_alpha4
%%Multipltying to get the T matrix we get

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$$T = A_1 A_2 A_3 A_4$$

$$A_1 =$$

$$\begin{bmatrix} \cos(\pi\theta_1/180) & -\sin(\pi\theta_1/180) & 0 & 0 \\ 11\cos(\pi\theta_1/180) & 11\sin(\pi\theta_1/180) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A_2 =$$

$$\begin{bmatrix} \cos(\pi\theta_2/180) & -\sin(\pi\theta_2/180) & 0 & 0 \\ 12\cos(\pi\theta_2/180) & 12\sin(\pi\theta_2/180) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A_3 =$$

$$\begin{bmatrix} \cos(\pi\theta_3/180) & 0 & -\sin(\pi\theta_3/180) & 0 \\ 13\cos(\pi\theta_3/180) & 0 & 13\sin(\pi\theta_3/180) & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A_4 =$$

$$\begin{bmatrix} 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 0 & 1 & d_4 + l_4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T =$$

$$\begin{bmatrix} 0 & \cos(\pi\theta_3/180)(\cos(\pi\theta_1/180)\cos(\pi\theta_2/180) - \sin(\pi\theta_1/180)\sin(\pi\theta_2/180)) - \sin(\pi\theta_3/180)(\cos(\pi\theta_1/180)\sin(\pi\theta_2/180) + \cos(\pi\theta_2/180)\sin(\pi\theta_1/180)), & -\cos(\pi\theta_3/180)(\cos(\pi\theta_1/180)\sin(\pi\theta_2/180) \end{bmatrix}$$

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+ cos((pi*theta2)/180)*sin((pi*theta1)/180)) -
sin((pi*theta3)/180)*(cos((pi*theta1)/180)*cos((pi*theta2)/180)
- sin((pi*theta1)/180)*sin((pi*theta2)/180)),
l1*cos((pi*theta1)/180) - (d4 +
l4)*(cos((pi*theta3)/180)*(cos((pi*theta1)/180)*sin((pi*theta2)/180)
+ cos((pi*theta2)/180)*sin((pi*theta1)/180)) +
sin((pi*theta3)/180)*(cos((pi*theta1)/180)*cos((pi*theta2)/180)
- sin((pi*theta1)/180)*sin((pi*theta2)/180))) +
l3*cos((pi*theta3)/180)*(cos((pi*theta1)/180)*cos((pi*theta2)/180)
- sin((pi*theta1)/180)*sin((pi*theta2)/180)) -
l3*sin((pi*theta3)/180)*(cos((pi*theta1)/180)*sin((pi*theta2)/180)
+ cos((pi*theta2)/180)*sin((pi*theta1)/180)) +
l2*cos((pi*theta1)/180)*cos((pi*theta2)/180) -
l2*sin((pi*theta1)/180)*sin((pi*theta2)/180)]
[ 0, cos((pi*theta3)/180)*(cos((pi*theta1)/180)*sin((pi*theta2)/180)
+ cos((pi*theta2)/180)*sin((pi*theta1)/180)) +
sin((pi*theta3)/180)*(cos((pi*theta1)/180)*cos((pi*theta2)/180)
- sin((pi*theta1)/180)*sin((pi*theta2)/180)),
cos((pi*theta3)/180)*(cos((pi*theta1)/180)*cos((pi*theta2)/180)
- sin((pi*theta1)/180)*sin((pi*theta2)/180)) -
sin((pi*theta3)/180)*(cos((pi*theta1)/180)*sin((pi*theta2)/180)
+ cos((pi*theta2)/180)*sin((pi*theta1)/180)),
l1*sin((pi*theta1)/180) + (d4 +
l4)*(cos((pi*theta3)/180)*(cos((pi*theta1)/180)*cos((pi*theta2)/180)
- sin((pi*theta1)/180)*sin((pi*theta2)/180)) -
sin((pi*theta3)/180)*(cos((pi*theta1)/180)*sin((pi*theta2)/180)
+ cos((pi*theta2)/180)*sin((pi*theta1)/180))) +
l3*cos((pi*theta3)/180)*(cos((pi*theta1)/180)*sin((pi*theta2)/180)
+ cos((pi*theta2)/180)*sin((pi*theta1)/180)) +
l3*sin((pi*theta3)/180)*(cos((pi*theta1)/180)*cos((pi*theta2)/180)
- sin((pi*theta1)/180)*sin((pi*theta2)/180)) +
l2*cos((pi*theta1)/180)*sin((pi*theta2)/180) +
l2*cos((pi*theta2)/180)*sin((pi*theta1)/180)]
[ 1,

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0,

0,

0]

[0,

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$0,$

$1]$

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