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Kinematics and Dynamics of Mechatronic Systems

Lab 1.

Code:

```
% this script determines a Homogeneous Transformation matrix
clear all
% declaration of symbols
syms th1 d1 th2 a3 q1 q2
% determination of a symbolic form of HT matrices -
% application of mA function
A1=mA(th1,d1,0,sym(pi/2))
A2=mA(th2,0,0,0)
A3=mA(0,0,a3,0)
% multiplication of matrices
T03=A1*A2*A3
% substitution of rotational joint variables
% for the simplification purpose
T03v=subs(T03,{th1,th2},{q1,q2})
% indication of joint coordinates
% variables: th1,th2 and a3 indicated by '1's
zmie=[[1,0,0,0];[1,0,0,0];[0,0,1,0]]
% a simplified form of the evaluated HT matrices
% for interpretation purpose for a user
T03u=zam(zmie,T03v,'q')
% example of substitution of the join variables values
% and constant values into the T0e matrix for the RRP
manipulator example
% please use meters and radians
T03n=subs(T03,{th1,d1, th2,a3},{pi/6,0.4,pi/4,0.4})
```

T03 =

[cos(th1)*cos(th2), -cos(th1)*sin(th2), sin(th1), a3*cos(th1)*cos(th2)]

[cos(th2)*sin(th1), -sin(th1)*sin(th2), -cos(th1), a3*cos(th2)*sin(th1)]

[sin(th2), cos(th2), 0, d1 + a3*sin(th2)]

[0, 0, 0, 1]

T03v =

[cos(q1)*cos(q2), -cos(q1)*sin(q2), sin(q1), a3*cos(q1)*cos(q2)]

[cos(q2)*sin(q1), -sin(q1)*sin(q2), -cos(q1), a3*cos(q2)*sin(q1)]

[sin(q2), cos(q2), 0, d1 + a3*sin(q2)]

[0, 0, 0, 1]

T03u =

[C1*C2, -C1*S2, S1, C1*C2*a3]

[C2*S1, -S1*S2, -C1, C2*S1*a3]

[S2, C2, 0, d1 + S2*a3]

[0, 0, 0, 1]

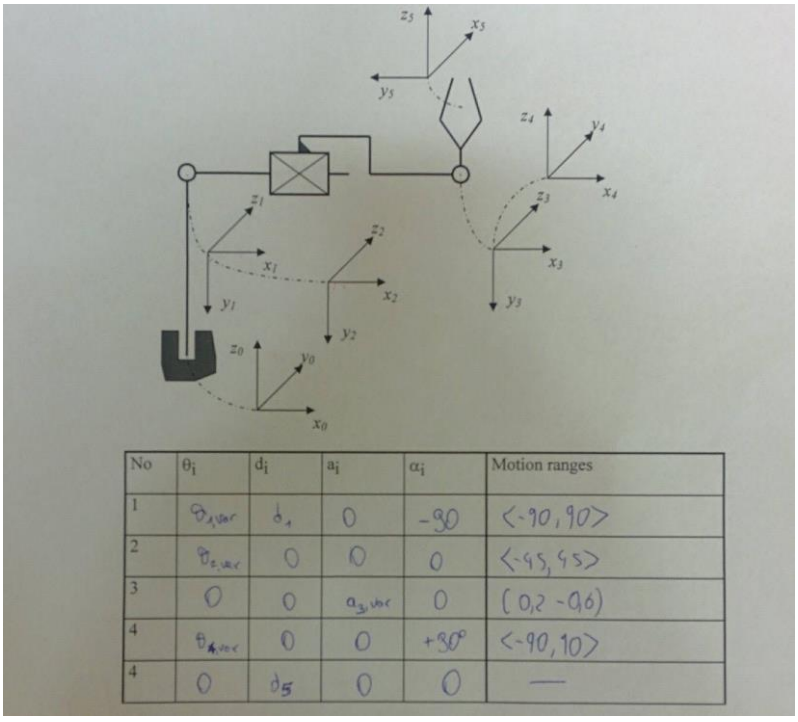
T03n =

[(2^(1/2)*3^(1/2))/4, -(2^(1/2)*3^(1/2))/4, 1/2, (2^(1/2)*3^(1/2))/10]

[2^(1/2)/4, -2^(1/2)/4, -3^(1/2)/2, 2^(1/2)/10]

[2^(1/2)/2, 2^(1/2)/2, 0, 2^(1/2)/5 + 2/5]

[0, 0, 0, 1]



No	θ_i	d_i	a_i	α_i	Motion ranges
1	$\theta_{1,var}$	d_1	0	-90	<-90,90>
2	$\theta_{2,var}$	0	0	0	<-45,45>
3	0	0	$a_{3,var}$	0	(0,2 -0,6)
4	$\theta_{4,var}$	0	0	+90°	<-90,10>
4	0	d_5	0	0	—

$$\overline{p}_a = {}^0\underline{T}_3 \, {}^3\overline{p}_a =$$

$$= \begin{bmatrix} \cos(\theta_1)\cdot\cos(\theta_2) & -\cos(\theta_1)\cdot\sin(\theta_2) & \sin(\theta_1) & a_3\cdot\cos(\theta_1)\cdot\cos(\theta_2) \\ \cos(\theta_2)\cdot\sin(\theta_1) & -\sin(\theta_1)\cdot\sin(\theta_2) & -\cos(\theta_1) & a_3\cdot\cos(\theta_2)\cdot\sin(\theta_1) \\ \sin(\theta_2) & \cos(\theta_2) & 0 & d_1 + a_3\cdot\sin(\theta_2) \\ 0 & 0 & 0 & 1 \end{bmatrix} * \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix}$$

$$\overline{p}_a = \begin{bmatrix} a_3\cdot\cos(\theta_1)\cdot\cos(\theta_2) \\ a_3\cdot\cos(\theta_2)\cdot\sin(\theta_1) \\ d_1 + a_3\cdot\sin(\theta_2) \\ 1 \end{bmatrix}$$

$${}^3\underline{T}_e = \begin{bmatrix} \cos(\theta_4) & 0 & \sin(\theta_4) & d_5\cdot\sin(\theta_4) \\ \sin(\theta_4) & 0 & -\cos(\theta_4) & -d_5\cdot\cos(\theta_4) \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Task 4.

Code:

```
% this script determines a Homogeneous Transformation matrix
clear all
% declaration of symbols
syms th1 d1 th2 a3 th4 d5 q1 q2 q3
% determination of a symbolic form of HT matrices -
% application of mA function
A1=mA(th1,d1,0,sym(pi/2));
A2=mA(th2,0,0,0);
A3=mA(0,0,a3,0);
A4=mA(th4,0,0,sym(pi/2));
A5=mA(0,d5,0,0);
% multiplication of matrices
T05=A1*A2*A3*A4*A5
% substitution of rotational joint variables
% for the simplification purpose
T05v=subs(T05,{th1,th2,th4},{q1,q2, q3})
% indication of joint coordinates
% variables: th1,th2 and a3 indicated by '1's
zmie=[[1,0,0,0];[1,0,0,0];[0,0,1,0];[1,0,0,0];[0,0,0,0]];
% a simplified form of the evaluated HT matrices
% for interpretation purpose for a user
T05u=zam(zmie,T05v,'q')

% example of substitution of the join variables values
% and constant values into the T0e matrix for the RRP
manipulator example
% please use meters and radians
T05n=subs(T05,{th1,d1,th2,a3,th4,d5},{pi/3,0.4,pi/4,0.2,pi/3,0
.1})
```

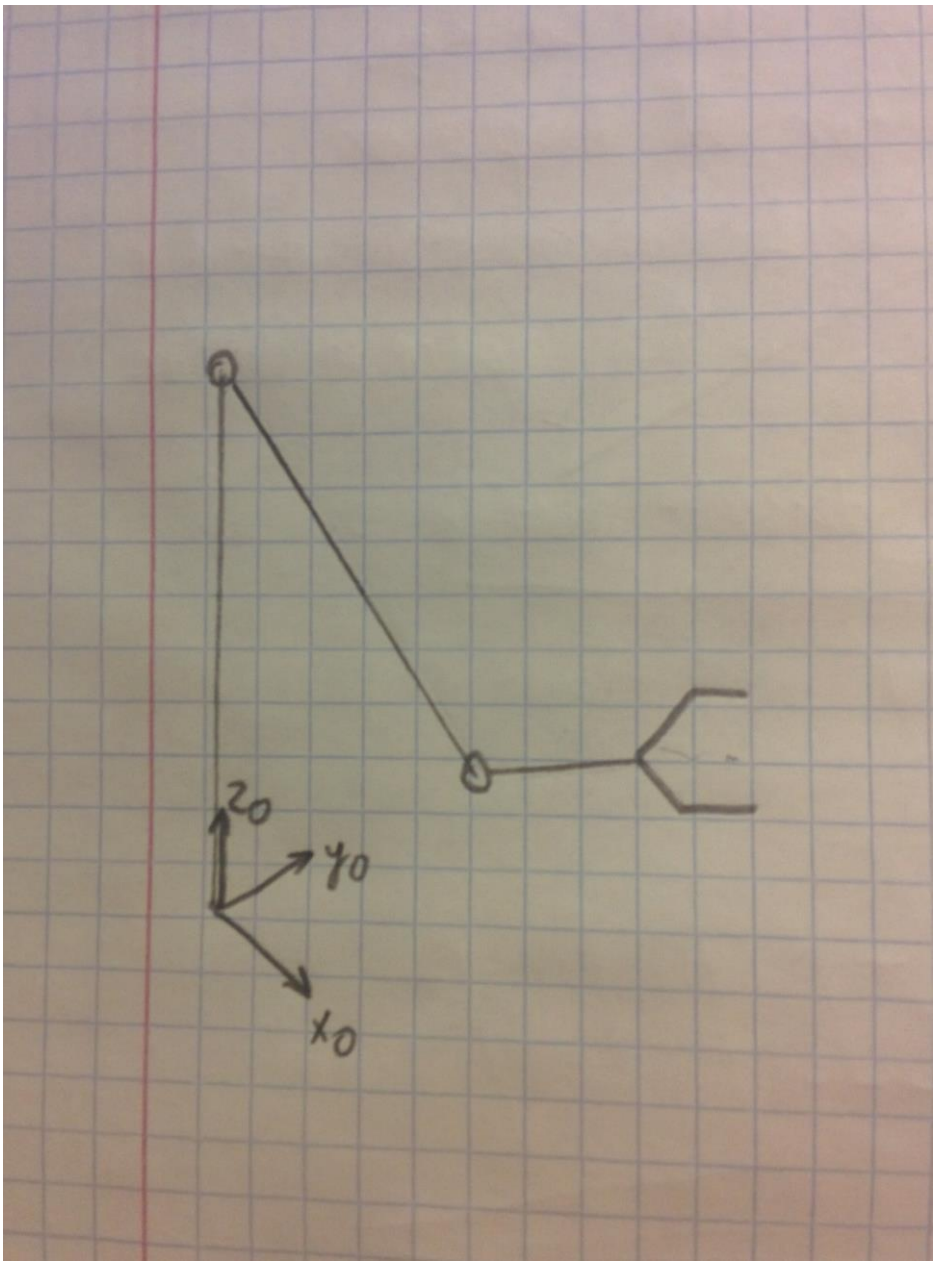
T05n =

[5^(1/2)/16 - (2^(1/2)*3^(1/2)*(5 - 5^(1/2))^(1/2))/16 + 1/16, 3^(1/2)/2, (2^(1/2)*(5 - 5^(1/2))^(1/2))/16 + (3^(1/2)*(5^(1/2)/4 + 1/4))/4, (2^(1/2)*(5 - 5^(1/2))^(1/2))/160 + 5^(1/2)/40 + (3^(1/2)*(5^(1/2)/4 + 1/4))/40 + 1/40]

[(3^(1/2)*(5^(1/2)/4 + 1/4))/4 - (3*2^(1/2)*(5 - 5^(1/2))^(1/2))/16, -1/2, (3*5^(1/2))/16 + (2^(1/2)*3^(1/2)*(5 - 5^(1/2))^(1/2))/16 + 3/16, (3*5^(1/2))/160 + (3^(1/2)*(5^(1/2)/4 + 1/4))/10 + (2^(1/2)*3^(1/2)*(5 - 5^(1/2))^(1/2))/160 + 3/160]

[(2^(1/2)*(5 - 5^(1/2))^(1/2))/8 + (3^(1/2)*(5^(1/2)/4 + 1/4))/2, 0, (2^(1/2)*3^(1/2)*(5 - 5^(1/2))^(1/2))/8 - 5^(1/2)/8 - 1/8, (2^(1/2)*(5 - 5^(1/2))^(1/2))/20 - 5^(1/2)/80 + (2^(1/2)*3^(1/2)*(5 - 5^(1/2))^(1/2))/80 + 31/80]

[0, 0, 0, 1]


z0
y0
x0