```
clear; close; clc;
```

DH-parametere for to robotarmer.

```
% Vi tar utgangspunkt i DH-parameterene til UR5, med untak av 'a' verdiane
% Vi tar 'a' verdiane frå UR10

% Sida vi ønsker to identiske robotarmer bruker vi same verdier for dei,
% med unntak av 'q'

% Vi løyser symbolsk her, so då blir og løysinga for begge
% robotane like og vi treng berre å løyse for eine for å ha for begge.
syms q1 q2 q3 q4 q5 q6 ;
syms d1 d4 d5 d6 ;
syms a2 a3 ;
syms alpha1 alpha4 alpha5  ;
d2=0; d3=0;
a1=0; a4=0; a5=0; a6=0;
alpha2=0; alpha3=0; alpha6=0;
% q1=0; q2=deg2rad(40); q3=0; q4=0; q5=0; q6=0;
% d1=0.089459; d2=0; d3=0; d4=0.10915; d5=0.09465; d6=0.0823;
% a1=0; a2=-0.612; a3=-0.5723; a4=0; a5=0; a6=0;
% alpha1=1.5708; alpha2=0; alpha3=0; alpha4=1.5708; alpha5=-1.5708; alpha6=0;
```

Forward Kinematics

```
% Transformasjon frå 0 til 1
Transf0til1 = ([cos(q1) (-sin(q1)*cos(alpha1)) (sin(q1)*sin(alpha1)) (a1*cos(q1)); ...
    sin(q1) (cos(q1)*cos(alpha1)) (-cos(q1)*sin(alpha1)) (a1*sin(q1)); ...
    0 sin(alpha1) cos(alpha1) d1; ...
    0 0 0 1;])
```

```
Transf0til1 =
```

$$\begin{pmatrix} \cos(q_1) & -\cos(\alpha_1)\sin(q_1) & \sin(\alpha_1)\sin(q_1) & 0 \\ \sin(q_1) & \cos(\alpha_1)\cos(q_1) & -\cos(q_1)\sin(\alpha_1) & 0 \\ 0 & \sin(\alpha_1) & \cos(\alpha_1) & d_1 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

```
Transf1til2 = ([cos(q2) (-sin(q2)*cos(alpha2)) (sin(q2)*sin(alpha2)) (a2*cos(q2)); ...
    sin(q2) (cos(q2)*cos(alpha2)) (-cos(q2)*sin(alpha2)) (a2*sin(q2)); ...
    0 sin(alpha2) cos(alpha2) d2; ...
    0 0 0 1;])
```

```
Transf1til2 =
```

$$\begin{pmatrix} \cos(q_2) & -\sin(q_2) & 0 & a_2\cos(q_2) \\ \sin(q_2) & \cos(q_2) & 0 & a_2\sin(q_2) \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

```
Transf2til3 = ([cos(q3) (-sin(q3)*cos(alpha3)) (sin(q3)*sin(alpha3)) (a3*cos(q3)); ...
    sin(q3) (cos(q3)*cos(alpha3)) (-cos(q3)*sin(alpha3)) (a3*sin(q3)); ...
    0 sin(alpha3) cos(alpha3) d3; ...
```

```
    0 0 0 1;])
```

Transf2til3 =

$$\begin{pmatrix} \cos(q_3) & -\sin(q_3) & 0 & a_3\cos(q_3) \\ \sin(q_3) & \cos(q_3) & 0 & a_3\sin(q_3) \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

```
Transf3til4 = ([cos(q4) (-sin(q4)*cos(alpha4)) (sin(q4)*sin(alpha4)) (a4*cos(q4)); ...
    sin(q4) (cos(q4)*cos(alpha4)) (-cos(q4)*sin(alpha4)) (a4*sin(q4)); ...
    0 sin(alpha4) cos(alpha4) d4; ...
    0 0 0 1;])
```

Transf3til4 =

$$\begin{pmatrix} \cos(q_4) & -\cos(\alpha_4)\sin(q_4) & \sin(\alpha_4)\sin(q_4) & 0 \\ \sin(q_4) & \cos(\alpha_4)\cos(q_4) & -\cos(q_4)\sin(\alpha_4) & 0 \\ 0 & \sin(\alpha_4) & \cos(\alpha_4) & d_4 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

```
Transf4til5 = ([cos(q5) (-sin(q5)*cos(alpha5)) (sin(q5)*sin(alpha5)) (a5*cos(q5)); ...
    sin(q5) (cos(q5)*cos(alpha5)) (-cos(q5)*sin(alpha5)) (a5*sin(q5)); ...
    0 sin(alpha5) cos(alpha5) d5; ...
    0 0 0 1;])
```

Transf4til5 =

$$\begin{pmatrix} \cos(q_5) & -\cos(\alpha_5)\sin(q_5) & \sin(\alpha_5)\sin(q_5) & 0 \\ \sin(q_5) & \cos(\alpha_5)\cos(q_5) & -\cos(q_5)\sin(\alpha_5) & 0 \\ 0 & \sin(\alpha_5) & \cos(\alpha_5) & d_5 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

```
Transf5til6 = ([cos(q6) (-sin(q6)*cos(alpha6)) (sin(q6)*sin(alpha6)) (a6*cos(q6)); ...
    sin(q6) (cos(q6)*cos(alpha6)) (-cos(q6)*sin(alpha6)) (a6*sin(q6)); ...
    0 sin(alpha6) cos(alpha6) d6; ...
    0 0 0 1;])
```

Transf5til6 =

$$\begin{pmatrix} \cos(q_6) & -\sin(q_6) & 0 & 0 \\ \sin(q_6) & \cos(q_6) & 0 & 0 \\ 0 & 0 & 1 & d_6 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

```
Transf0til1*Transf1til2*Transf2til3*Transf3til4*Transf4til5*Transf5til6
```

ans =

$$\begin{pmatrix} \cos(q_6)\,\sigma_5 - \sin(q_6)\,\sigma_2 & -\sin(q_6)\,\sigma_5 - \cos(q_6)\,\sigma_2 & \sigma_1 & d_5\,\sigma_{10} + d_6\,\sigma_1 + a_2\cos(q_1)\cos(q_2) + d_4\sin(\alpha_1) \\ \cos(q_6)\,\sigma_6 - \sin(q_6)\,\sigma_4 & -\cos(q_6)\,\sigma_4 - \sin(q_6)\,\sigma_6 & \sigma_3 & d_5\,\sigma_{11} + d_6\,\sigma_3 - d_4\cos(q_1)\sin(\alpha_1) + a_2\cos(q_2) \\ \cos(q_6)\,\sigma_9 + \sin(q_6)\,\sigma_8 & \cos(q_6)\,\sigma_8 - \sin(q_6)\,\sigma_9 & \sigma_7 & d_1 + d_6\,\sigma_7 + d_4\cos(\alpha_1) + d_5\,\sigma_{16} + a_2\sin(\alpha_1) \\ 0 & 0 & 0 & \end{pmatrix}$$

where

$$\sigma_1 = \cos(\alpha_5)\,\sigma_{10} + \cos(q_5)\sin(\alpha_5)\,\sigma_{12} + \sin(\alpha_5)\sin(q_5)\,\sigma_{13}$$

$$\sigma_2 = \cos(\alpha_5)\cos(q_5)\,\sigma_{12} - \sin(\alpha_5)\,\sigma_{10} + \cos(\alpha_5)\sin(q_5)\,\sigma_{13}$$

$$\sigma_3 = \cos(\alpha_5)\,\sigma_{11} + \cos(q_5)\sin(\alpha_5)\,\sigma_{14} + \sin(\alpha_5)\sin(q_5)\,\sigma_{15}$$

$$\sigma_4 = \cos(\alpha_5)\cos(q_5)\,\sigma_{14} - \sin(\alpha_5)\,\sigma_{11} + \cos(\alpha_5)\sin(q_5)\,\sigma_{15}$$

$$\sigma_5 = \cos(q_5)\,\sigma_{13} - \sin(q_5)\,\sigma_{12}$$

$$\sigma_6 = \cos(q_5)\,\sigma_{15} - \sin(q_5)\,\sigma_{14}$$

$$\sigma_7 = \cos(\alpha_5)\,\sigma_{16} + \sin(\alpha_5)\sin(q_5)\,\sigma_{18} - \cos(q_5)\sin(\alpha_5)\,\sigma_{17}$$

$$\sigma_8 = \sin(\alpha_5)\,\sigma_{16} - \cos(\alpha_5)\sin(q_5)\,\sigma_{18} + \cos(\alpha_5)\cos(q_5)\,\sigma_{17}$$

$$\sigma_9 = \sin(q_5)\,\sigma_{17} + \cos(q_5)\,\sigma_{18}$$

$$\sigma_{10} = \cos(q_4)\sin(\alpha_4)\,\sigma_{20} + \sin(\alpha_4)\sin(q_4)\,\sigma_{19} + \cos(\alpha_4)\sin(\alpha_1)\sin(q_1)$$

$$\sigma_{11} = \cos(q_4)\sin(\alpha_4)\,\sigma_{22} + \sin(\alpha_4)\sin(q_4)\,\sigma_{21} - \cos(\alpha_4)\cos(q_1)\sin(\alpha_1)$$

$$\sigma_{12} = \cos(\alpha_4)\cos(q_4)\,\sigma_{20} + \cos(\alpha_4)\sin(q_4)\,\sigma_{19} - \sin(\alpha_1)\sin(\alpha_4)\sin(q_1)$$

$$\sigma_{13} = \cos(q_4)\,\sigma_{19} - \sin(q_4)\,\sigma_{20}$$

$$\sigma_{14} = \cos(\alpha_4)\cos(q_4)\,\sigma_{22} + \cos(\alpha_4)\sin(q_4)\,\sigma_{21} + \cos(q_1)\sin(\alpha_1)\sin(\alpha_4)$$

$$\sigma_{15} = \cos(q_4)\,\sigma_{21} - \sin(q_4)\,\sigma_{22}$$

$$\sigma_{16} = \cos(\alpha_1)\cos(\alpha_4) - \cos(q_4)\sin(\alpha_4)\,\sigma_{23} + \sin(\alpha_4)\sin(q_4)\,\sigma_{24}$$

$$\sigma_{17} = \cos(\alpha_1)\sin(\alpha_4) + \cos(\alpha_4)\cos(q_4)\,\sigma_{23} - \cos(\alpha_4)\sin(q_4)\,\sigma_{24}$$

$$\sigma_{18} = \cos(q_4)\,\sigma_{24} + \sin(q_4)\,\sigma_{23}$$

$$\sigma_{19} = \cos(q_3)\,\sigma_{25} - \sin(q_3)\,\sigma_{26}$$

$$\sigma_{20} = \cos(q_3)\,\sigma_{26} + \sin(q_3)\,\sigma_{25}$$

$$\sigma_{21} = \cos(q_3)\,\sigma_{28} - \sin(q_3)\,\sigma_{27}$$

$$\sigma_{22} = \cos(q_3)\,\sigma_{27} + \sin(q_3)\,\sigma_{28}$$

$$\sigma_{23} = \cos(q_2)\cos(q_3)\sin(\alpha_1) - \sin(\alpha_1)\sin(q_2)\sin(q_3)$$

$$\sigma_{24} = \cos(q_2)\sin(\alpha_1)\sin(q_3) + \cos(q_3)\sin(\alpha_1)\sin(q_2)$$

$$\sigma_{25} = \cos(q_1)\cos(q_2) - \cos(\alpha_1)\sin(q_1)\sin(q_2)$$

$$\sigma_{26} = \cos(q_1)\sin(q_2) + \cos(\alpha_1)\cos(q_2)\sin(q_1)$$

$$\sigma_{27} = \sin(q_1)\sin(q_2) - \cos(\alpha_1)\cos(q_1)\cos(q_2)$$

$$\sigma_{28} = \cos(q_2)\sin(q_1) + \cos(\alpha_1)\cos(q_1)\sin(q_2)$$