HOMEWORK - 03

2. Position Kinematics - KUKA [1.5 points]

In [1]:
```python
from sympy import *
from IPython.display import Image,display,HTML
init_printing()

theta,d,a,alpha=symbols('theta,d,a,alpha')
d_1,d_3,d_5,d_7,a_3=symbols('d_1,d_3,d_5,d_7,a_3')
theta_1,theta_2,theta_3,theta_4,theta_5,theta_6,theta_7=symbols('theta_1,theta_2,theta_3,theta_4,theta_5,theta_6,theta_7')
Rot_z_theta=Matrix([[cos(theta),-sin(theta),0,0],
                    [sin(theta),cos(theta),0,0],
                    [0,0,1,0],
                    [0,0,0,1]])
Trans_z_d=Matrix([[1,0,0,0],
                  [0,1,0,0],
                  [0,0,1,d],
                  [0,0,0,1]])
Trans_x_a=Matrix([[1,0,0,a],
                  [0,1,0,0],
                  [0,0,1,0],
                  [0,0,0,1]])
Rot_x_alpha=Matrix([[1,0,0,0],
                   [0,cos(alpha),-sin(alpha),0],
                   [0,sin(alpha),cos(alpha),0],
                   [0,0,0,1]])

A=Rot_z_theta*Trans_z_d*Trans_x_a*Rot_x_alpha
A
```

Out[1]:

$$\begin{bmatrix} \cos(\theta) & -\sin(\theta)\cos(\alpha) & \sin(\alpha)\sin(\theta) & a\cos(\theta) \\ \sin(\theta) & \cos(\alpha)\cos(\theta) & -\sin(\alpha)\cos(\theta) & a\sin(\theta) \\ 0 & \sin(\alpha) & \cos(\alpha) & d \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

In [2]:
```python
A_1=A.subs({theta:((1.5*pi)+theta_1),d:d_1,a:0,alpha:-pi/2})
A_2=A.subs({theta:theta_2,d:0,a:0,alpha:pi/2})
A_3=A.subs({theta:theta_3,d:d_3,a:0,alpha:pi/2})
A_4=A.subs({theta:theta_4,d:0,a:0,alpha:-pi/2})
A_5=A.subs({theta:theta_5,d:d_5,a:0,alpha:-pi/2})
A_6=A.subs({theta:theta_6,d:0,a:0,alpha:pi/2})
A_7=A.subs({theta:theta_7,d:d_7,a:0,alpha:0})
```

In [3]:
```python
Transformation=A_1*A_2*A_3*A_4*A_5*A_6*A_7
Transformation
```

Out[3]:

$$((((-\sin(\theta_3)\sin(\theta_1+1.5\pi)+\cos(\theta_2)\cos(\theta_3)\cos(\theta_1+1.5\pi))\cos(\theta_4)+\sin(\theta_2)\sin(\theta_4)\cos(\theta_1+1.5\pi))\cos(\theta_5)+(-\sin(\theta_3)\cos(\theta_2)\cos(\theta_1+1.5\pi)-\sin(\theta_1+1.5\pi)\cos(\theta_3$$
$$(\theta_6)+((-\sin(\theta_3)\sin(\theta_1+1.5\pi)+\cos(\theta_2)\cos(\theta_3)\cos(\theta_1+1.5\pi))\sin(\theta_4)-\sin(\theta_2)\cos(\theta_4)\cos(\theta_1+1.5\pi))\sin(\theta_6))\cos(\theta_7)$$
$$+(-((-\sin(\theta_3)\sin(\theta_1+1.5\pi)+\cos(\theta_2)\cos(\theta_3)\cos(\theta_1+1.5\pi))\cos(\theta_4)+\sin(\theta_2)\sin(\theta_4)\cos(\theta_1+1.5\pi))\sin(\theta_5)+(-\sin(\theta_3)\cos(\theta_2)\cos(\theta_1+1.5\pi)-\sin(\theta_1+1.5\pi)\cos($$
$$(\theta_7)$$
$$((((\sin(\theta_3)\cos(\theta_1+1.5\pi)+\sin(\theta_1+1.5\pi)\cos(\theta_2)\cos(\theta_3))\cos(\theta_4)+\sin(\theta_2)\sin(\theta_4)\sin(\theta_1+1.5\pi))\cos(\theta_5)+(-\sin(\theta_3)\sin(\theta_1+1.5\pi)\cos(\theta_2)+\cos(\theta_3)\cos(\theta_1+1$$
$$(\theta_5))\cos(\theta_6)+((\sin(\theta_3)\cos(\theta_1+1.5\pi)+\sin(\theta_1+1.5\pi)\cos(\theta_2)\cos(\theta_3))\sin(\theta_4)-\sin(\theta_2)\sin(\theta_1+1.5\pi)\cos(\theta_4))\sin(\theta_6))\cos(\theta_7)$$
$$+(-((\sin(\theta_3)\cos(\theta_1+1.5\pi)+\sin(\theta_1+1.5\pi)\cos(\theta_2)\cos(\theta_3))\cos(\theta_4)+\sin(\theta_2)\sin(\theta_4)\sin(\theta_1+1.5\pi))\sin(\theta_5)+(-\sin(\theta_3)\sin(\theta_1+1.5\pi)\cos(\theta_2)+\cos(\theta_3)\cos(\theta_1+1.5$$
$$(\theta_7)$$
$$(((-\sin(\theta_2)\cos(\theta_3)\cos(\theta_4)+\sin(\theta_4)\cos(\theta_2))\cos(\theta_5)+\sin(\theta_2)\sin(\theta_3)\sin(\theta_5))\cos(\theta_6)+(-\sin(\theta_2)\sin(\theta_4)\cos(\theta_3)-\cos(\theta_2)\cos(\theta_4))\sin(\theta_6))\cos(\theta_7)$$
$$+(-(-\sin(\theta_2)\cos(\theta_3)\cos(\theta_4)+\sin(\theta_4)\cos(\theta_2))\sin(\theta_5)+\sin(\theta_2)\sin(\theta_3)\cos(\theta_5))\sin(\theta_7)$$
$$0$$

THIS IS THE HOME CONFIGRATION FOR THE ROBOT

In [4]:
```python
T_1=Transformation.subs({theta_1:0,
theta_2:0,
theta_3:0,
theta_4:0,
theta_5:0,
theta_6:0,
theta_7:0})
T_1
```

Out[4]:

$$\begin{bmatrix} 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 0 & 1 & d_1+d_3+d_5+d_7 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

In [ ]: