In [4]:
```
import numpy as np
import sympy as sym
from sympy import *
from IPython.display import display
init_printing(use_latex='mathjax')
```

Function used to systematically calculate A_i^{i-1} for verifying the joint coordinates in our code

In [5]:
```
def createA(DH4):
    a=DH4[0]
    alpha=DH4[1]
    d=DH4[2]
    theta=DH4[3]
    row1=[cos(theta),-sin(theta)*cos(alpha),sin(theta)*sin(alpha),a*cos(theta
)]
    row2=[sin(theta),cos(theta)*cos(alpha),-cos(theta)*sin(alpha),a*sin(theta
)]
    row3=[0,sin(alpha),cos(theta),d]
    row4=[0,0,0,1]
    Ai_1i=Matrix([row1,row2,row3,row4])
    return Ai_1i
```

Defines the link parameters for each link to check symbolically against matlab code.

In [6]:
```
link1=[0,-pi/2,symbols("L{1}"),symbols("theta1")]
link2=[symbols("-L_{2}"),0,0,symbols("theta2")+pi/2]
link3=[symbols("-L_{3}"),0,0,symbols("theta3")+pi/2]
link4=[0,pi/2,0,symbols("theta4")-pi/2]
linke=[0,0,symbols("L_{4+5}"),symbols("theta5")+pi]
testlink=[symbols("a_{1}"),symbols("alpha1"),symbols("d_{1}"),symbols("theta1"
)]
```

In [7]:
```
T1=createA(link1)
T2=createA(link2)
T3=createA(link3)
T4=createA(link4)
T5=createA(linke)
test=createA(testlink)
```

Example of displaying T_1^0 we could enter T1,T2,etc to display the corresponding matrix

In [10]:
```
display(T1)
```

$$\begin{bmatrix} \cos(\theta_1) & 0 & -\sin(\theta_1) & 0 \\ \sin(\theta_1) & 0 & \cos(\theta_1) & 0 \\ 0 & -1 & \cos(\theta_1) & L1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

This is why analytically writing T_e^0 is unfeasible. This monstrous section is just part of the first collumn.

In [13]:
```
display(T1*T2*T3*T4*T5)
```

$$\begin{bmatrix} -((\sin(\theta_2)\sin(\theta_3)\cos(\theta_1) - \cos(\theta_1)\cos(\theta_2)\cos(\theta_3))\sin(\theta_4) - (\sin(\theta_2)\cos \\ + \sin(\theta_1)\sin(\theta_2)\sin(\theta_3)\text{si} \\ \\ -((\sin(\theta_1)\sin(\theta_2)\sin(\theta_3) - \sin(\theta_1)\cos(\theta_2)\cos(\theta_3))\sin(\theta_4) - (\sin(\theta_1)\sin(\theta_2 \\ (\theta_2)\sin(\theta_3)\sin(\theta_5)\cos(\\ \\ -(-(-\sin(\theta_2)\sin(\theta_3) + \cos(\theta_2)\cos(\theta_3))\cos(\theta_4) + (\sin(\theta_2)\cos(\theta_3) + \sin(\theta \\ (\theta_1) \\ \\ 0 \end{bmatrix}$$

In [ ]:
```

```