```
% Defining the variables: Angle q, length l_0, length l_1, length l_2
syms q l_0 l_1 l_2 l_ee
%q = 0;
%l_0 = 0.6;
%l_1 = 3;
%l_2 = 0.9;
%l_ee = 2;
% From frame 0 to frame 1
T0_1 = [cos(q) -sin(q) 0 0; sin(q) cos(q) 0 0; 0 0 1 l_0; 0 0 0 1]
```

T0_1 =

$$\begin{pmatrix} \cos(q) & -\sin(q) & 0 & 0 \\ \sin(q) & \cos(q) & 0 & 0 \\ 0 & 0 & 1 & l_0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

```
% From frame 1 to frame 2
T1_2 = [1 0 0 0; 0 0 1 0; 0 -1 0 l_1; 0 0 0 1]
```

T1_2 =

$$\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & -1 & 0 & l_1 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

```
% From frame 2 to frame 3
T2_3 = [1 0 0 0; 0 0 1 0; 0 -1 0 l_2; 0 0 0 1]
```

T2_3 =

$$\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & -1 & 0 & l_2 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

```
% From frame 3 to end effector frame
T3_4 = [1 0 0 0; 0 1 0 0; 0 0 1 l_ee; 0 0 0 1]
```

T3_4 =

$$\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & l_{ee} \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

```
% End effector pose
TEE = T0_1 * T1_2 * T2_3 * T3_4;
```

```
% Display TEE with 3 decimal places
TEE_vpa = vpa(TEE, 3);
disp('TEE matrix with 5 decimal places:');
```

```
TEE matrix with 5 decimal places:
```

```
disp(TEE_vpa);
```

$$\begin{pmatrix} \cos(q) & \sin(q) & 0 & -1.0\, l_2 \sin(q) \\ \sin(q) & -1.0\cos(q) & 0 & l_2 \cos(q) \\ 0 & 0 & -1.0 & l_0 + l_1 - 1.0\, l_{ee} \\ 0 & 0 & 0 & 1.0 \end{pmatrix}$$

```
%final pose
position = TEE(1:3, 4);
position_vpa = vpa(position, 3)
```

```
position_vpa =
```

$$\begin{pmatrix} -1.0\, l_2 \sin(q) \\ l_2 \cos(q) \\ l_0 + l_1 - 1.0\, l_{ee} \end{pmatrix}$$

```
orientation = TEE(1:3, 1:3);
orientation_vpa = vpa(orientation, 3)% Extract the 3x3 rotation matrix
```

```
orientation_vpa =
```

$$\begin{pmatrix} \cos(q) & \sin(q) & 0 \\ \sin(q) & -1.0\cos(q) & 0 \\ 0 & 0 & -1.0 \end{pmatrix}$$

```
%Inverse Kinematics
%Desired end effector pose

% Define symbolic variables
syms e_1 e_2 e_ee

% Constants
x = 2;
y = 2;
z = 3;
l0 = 1;
angle = atan(x / y)*180/pi % Compute q numerically
```

```
angle = 45
```

```

% Define equations
l2 = y/cos(angle)
```

```
l2 = 3.8072
```

```
dif_l1lee = z-l0
```

```
dif_l1lee = 2
```