

Appendix

Part A

```
clear all;
close all;
clc;
links = zeros(3,4);
A = ones(4,4,length(links(:,1)));
T = ones(4,4,length(links(:,1)));

%go to home
theta = [ 0 0 0 0 0 0 ];
links(1,:) = [ 150 degtorad(90) 475 degtorad(theta(1))];
links(2,:) = [ 720 0 0 degtorad(theta(2)+90)];
links(3,:) = [ 805 0 0 degtorad(theta(3)-90 )];
% links(4,:) = [ 0 0 0 theta(4)];
% links(5,:) = [ 0 -90 0 theta(5)];
% links(6,:) = [ 0 90 0 theta(6)];
%get the A and T matrix
A = getA(links)
```

Undefined function 'getA' for input arguments of type 'double'.

```
T = getT(A)

%plot
figure(1);
title('home position')
plotArm(T)
%
%
hold on;

for theta2 = -50:5:50
    for theta3 = -45:5:45
        theta = [0 theta2 theta3 ];
        links(1,:) = [ 150 degtorad(90) 475 degtorad(theta(1))];
        links(2,:) = [ 720 0 0 degtorad(theta(2)+90)];
        links(3,:) = [ 805 0 0 degtorad(theta(3)-90 )];

        %get the A and T matrix
        A = getA(links);
        T = getT(A);
        plot3( T(1,4,end),0,T(3,4,end)-50,'g*');
    end
end
```

Part E

```
clear all;
close all;
clc;
%links = zeros(3,4);
```

```
%A = ones(4,4,length(links(:,1)));
%T = ones(4,4,length(links(:,1)));

%go to home
syms theta1 theta2 theta3 a1 a2 a3 d1
theta = [ theta1 theta2 theta3 ]
```

$$\theta = (\theta_1 \quad \theta_2 \quad \theta_3)$$

```
links(1,:) = [ a1 90 d1 theta1]
```

$$\text{links} = (a_1 \quad 90 \quad d_1 \quad \theta_1)$$

```
links(2,:) = [ a2 0 0 theta2]
```

links =

$$\begin{pmatrix} a_1 & 90 & d_1 & \theta_1 \\ a_2 & 0 & 0 & \theta_2 \end{pmatrix}$$

```
links(3,:) = [ a3 0 0 theta3]
```

links =

$$\begin{pmatrix} a_1 & 90 & d_1 & \theta_1 \\ a_2 & 0 & 0 & \theta_2 \\ a_3 & 0 & 0 & \theta_3 \end{pmatrix}$$

```
A = getA(links)
```

A(:, :, 1) =

$$\begin{pmatrix} \cos(\theta_1) & -\cos(90) \sin(\theta_1) & \sin(90) \sin(\theta_1) & a_1 \cos(\theta_1) \\ \sin(\theta_1) & \cos(90) \cos(\theta_1) & -\sin(90) \cos(\theta_1) & a_1 \sin(\theta_1) \\ 0 & \sin(90) & \cos(90) & d_1 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

A(:, :, 2) =

$$\begin{pmatrix} \cos(\theta_2) & -\sin(\theta_2) & 0 & a_2 \cos(\theta_2) \\ \sin(\theta_2) & \cos(\theta_2) & 0 & a_2 \sin(\theta_2) \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

A(:, :, 3) =

$$\begin{pmatrix} \cos(\theta_3) & -\sin(\theta_3) & 0 & a_3 \cos(\theta_3) \\ \sin(\theta_3) & \cos(\theta_3) & 0 & a_3 \sin(\theta_3) \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

`T = getT(A)`

`T(:, :, 1) =`

$$\begin{pmatrix} \cos(\theta_1) & -\cos(90) \sin(\theta_1) & \sin(90) \sin(\theta_1) & a_1 \cos(\theta_1) \\ \sin(\theta_1) & \cos(90) \cos(\theta_1) & -\sin(90) \cos(\theta_1) & a_1 \sin(\theta_1) \\ 0 & \sin(90) & \cos(90) & d_1 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

`T(:, :, 2) =`

$$\begin{pmatrix} \cos(\theta_1) \cos(\theta_2) - \cos(90) \sin(\theta_1) \sin(\theta_2) & -\cos(\theta_1) \sin(\theta_2) - \cos(90) \cos(\theta_2) \sin(\theta_1) & \sin(90) \cos(\theta_2) \sin(\theta_1) \\ \cos(\theta_2) \sin(\theta_1) + \cos(90) \cos(\theta_1) \sin(\theta_2) & \cos(90) \cos(\theta_1) \cos(\theta_2) - \sin(\theta_1) \sin(\theta_2) & -\sin(90) \cos(\theta_1) \cos(\theta_2) \\ \sin(90) \sin(\theta_2) & \sin(90) \cos(\theta_2) & \cos(90) \sin(\theta_2) \\ 0 & 0 & 1 \end{pmatrix}$$

`T(:, :, 3) =`

$$\begin{pmatrix} \cos(\theta_3) \sigma_2 - \sin(\theta_3) \sigma_4 & -\cos(\theta_3) \sigma_4 - \sin(\theta_3) \sigma_2 \\ \cos(\theta_3) \sigma_3 - \sin(\theta_3) \sigma_1 & -\cos(\theta_3) \sigma_1 - \sin(\theta_3) \sigma_3 \\ \sin(90) \cos(\theta_2) \sin(\theta_3) + \sin(90) \cos(\theta_3) \sin(\theta_2) & \sin(90) \cos(\theta_2) \cos(\theta_3) - \sin(90) \sin(\theta_2) \sin(\theta_3) \\ 0 & 0 \end{pmatrix}$$

where

$$\sigma_1 = \sin(\theta_1) \sin(\theta_2) - \cos(90) \cos(\theta_1) \cos(\theta_2)$$

$$\sigma_2 = \cos(\theta_1) \cos(\theta_2) - \cos(90) \sin(\theta_1) \sin(\theta_2)$$

$$\sigma_3 = \cos(\theta_2) \sin(\theta_1) + \cos(90) \cos(\theta_1) \sin(\theta_2)$$

$$\sigma_4 = \cos(\theta_1) \sin(\theta_2) + \cos(90) \cos(\theta_2) \sin(\theta_1)$$