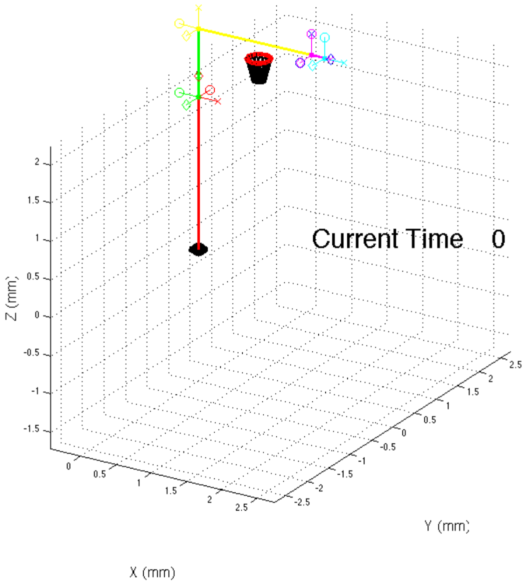
# Table of Contents

```
function z401ManipulatorDesign()

clear all
close all
clc

robot = basketInit();

% robot = robotInit array

% Cross-sectional areas of each arm member
d1 = robot.parameters.d_1;
d2 = robot.parameters.d_2;
d3 = robot.parameters.d_3;
d4 = robot.parameters.d_4;

A1 = pi/4*d1^2;
A2 = pi/4*d2^2;
A3 = pi/4*d3^2;
A4 = pi/4*d4^2;

% Other parameters
m1 = robot.parameters.m_1;
m2 = robot.parameters.m_2;
m3 = robot.parameters.m_3;
m4 = robot.parameters.m_4;
m5 = 0;

%Constants for deflection,SF
g = robot.const.g;
rho = robot.const.rho;
E = robot.const.E;
Sy = robot.const.Sy;


l1 = robot.parameters.l_1;
l2 = robot.parameters.l_2;
l3 = robot.parameters.l_3;
l4 = robot.parameters.l_4;

% Test joint torques at the zero position
```

```
joint_angles = [0;0;0;0;0];
joint_vel = [0;0;0;0;0];

%Draw robot in the given load case
drawBasket(joint_angles,[0;0;0],robot)

%Compare forces generated by code to FBD
[forces, moments]=z401ForceFinder(joint_angles,[0;0;0;0;0],[0;0;0;0;0])

[~, ~, G] = basketDynamics(joint_angles, joint_vel, robot);
tau = G;
```

```
        ans =

          Columns 1 through 7

          245.0024  255.0024  265.0024  275.0024  285.0024  295.0024  296.0024

          Columns 8 through 9

          532.0009  533.0009

        Velocity propagation for link 1
        Velocity propagation for link 2
        Velocity propagation for link 3
        Velocity propagation for link 4
        Velocity propagation for link 5
        Velocity propagation for link 6
        Calculating torques for joint 6
        Calculating torques for joint 5
        Calculating torques for joint 4
        Calculating torques for joint 3
        Calculating torques for joint 2
        Calculating torques for joint 1

        forces =

           -0.0000   50.1765   33.3262    3.3701         0         0
           -0.0000    0.0000    0.0000    0.0000    3.3701         0
           50.1765    0.0000    0.0000   -0.0000    0.0000         0


        moments =

            0.0000   -0.0000   -0.0000   -0.0000         0         0
          -29.6603   -0.0000    0.0000    0.3033   -0.0000         0
            0.0000   29.6603   29.6603    0.0000    0.3033         0
```

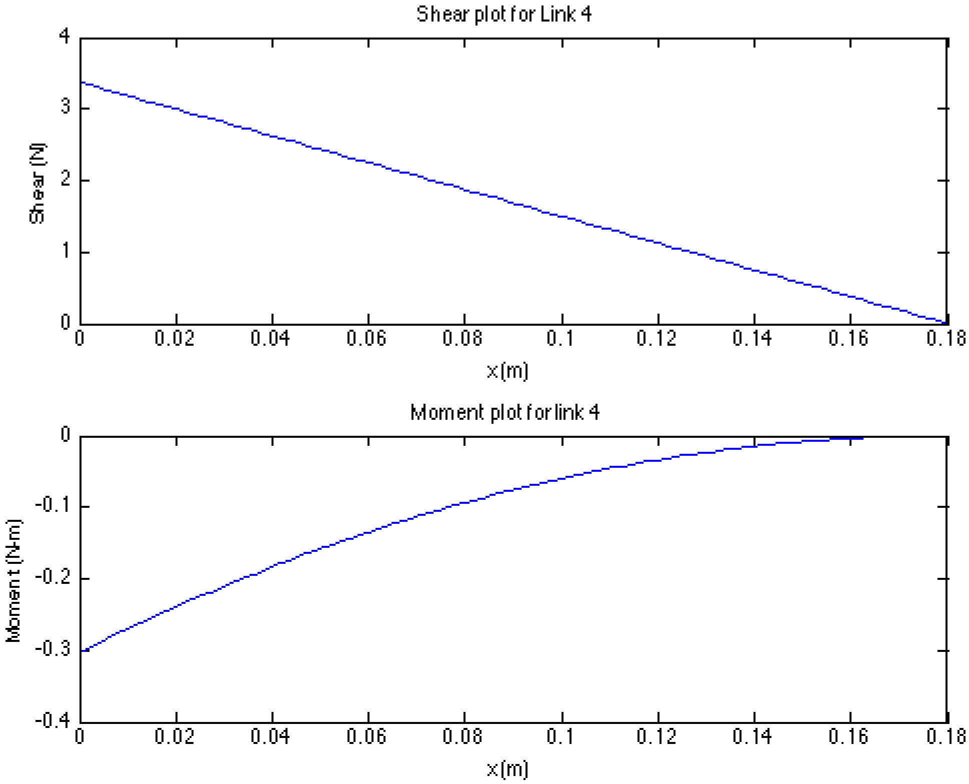


# Member 4

```
%George's inferior code

F5 = m4*g + m5*g;
% x4 = [0, l4/2, l4];
% shear4 = [F5, F5-m4*g, 0];
% moment4 = [tau(5), tau(5)+F5*l4/2, 0];
%
% stairs(x4,shear4);
% title('Member 4 Shear Diagram');
% xlabel('x (m)');
% ylabel('Shear (N)');
%
% figure
% plot(x4,moment4);
% title('Member 4 Moment Diagram');
% xlabel('x (m)');
% ylabel('Moment (N-m)');

%Treating weight as a distributed load

x=linspace(0,l4,100);
w=m4*g/l4;
V4=w*(l4-x);
M4=-w/2*(l4-x).^2;

%Deflection of the first member
%Ymax1=(-w*l4^4)/(8*E*I4)

%bending Stress
Mmax=max(m4)
```

```
c=d4/2
I4=(pi*d4^4)/64;
Sy
Sig_max=Mmax*c/I4
n=Sy/Sig_max

T5=w*l4^2/2;
F1=w*l4;

figure
subplot(2,1,1)
plot(x,V4)
xlabel('x (m)');
ylabel('Shear (N)');
title('Shear plot for Link 4')

subplot(2,1,2)
plot(x,M4)
xlabel('x (m)');
ylabel('Moment (N-m)');
title('Moment plot for link 4')
```

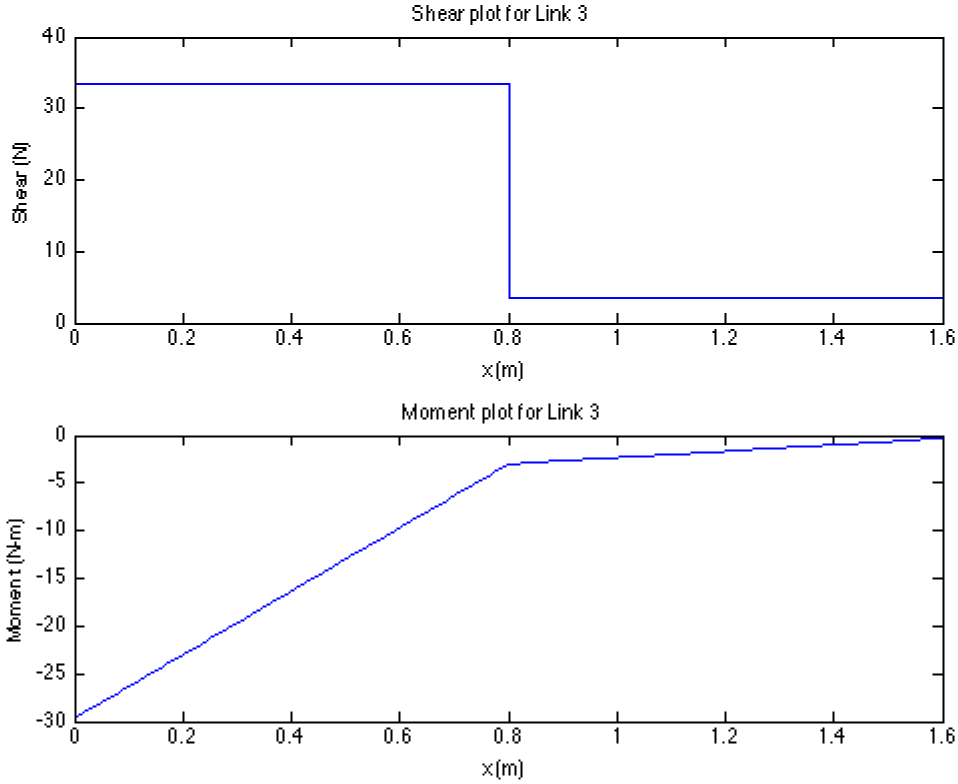
```
        Mmax =

            0.3435


        c =

            0.0150


        Sy =

          2.7600e+11


        Sig_max =

          1.2960e+05


        n =

          2.1296e+06
```



# Member 3

```
F3=m3*g+F5;

T3=m3*g*l3/2+T5+F5*l3;

x1=linspace(0,l3/2,50);
V31=F3+0*x1;
M31=F3*x1-T3;

x2=linspace(l3/2,l3,50);
V32=F5+0*x2;
M32=-F5*(l3-x2)-T5;

figure

subplot(2,1,1)
plot([x1 x2],[V31 V32],'-')
xlabel('x (m)');
ylabel('Shear (N)');
title('Shear plot for Link 3')

subplot(2,1,2)
plot([x1 x2],[M31 M32])
xlabel('x (m)');
```

```
ylabel('Moment (N-m)');
title('Moment plot for Link 3')
```



# Member 2

```
F2=F3+m2*g;

T2=T3;
```

# Member 1

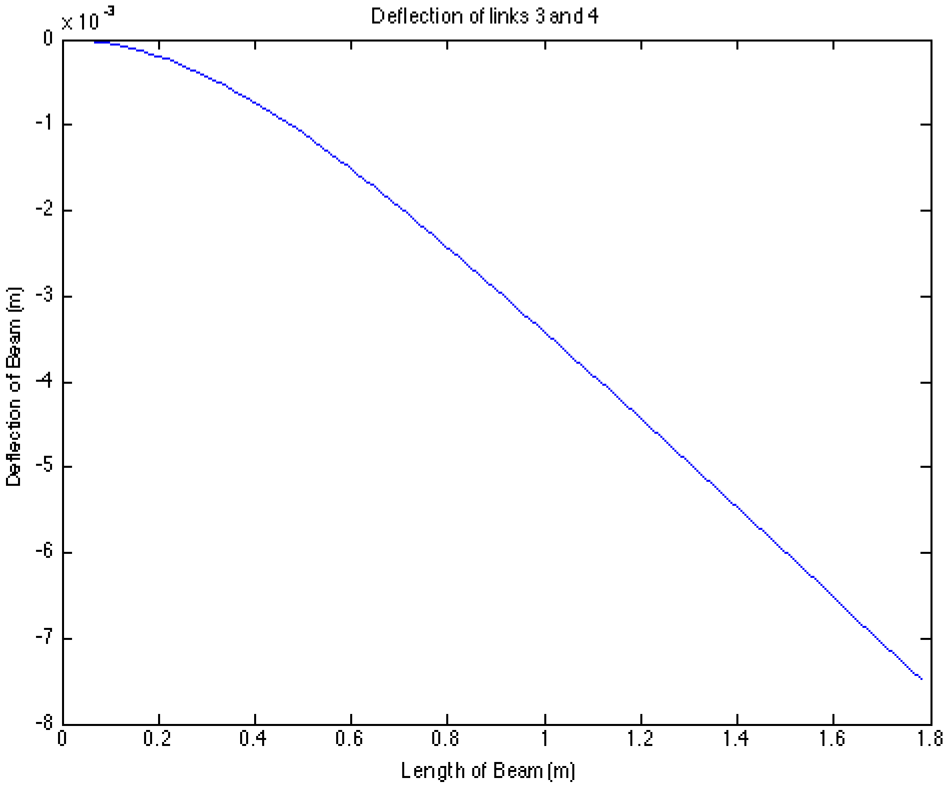
```
%Reaction forces at the ground
Rf=F2+m1*g;
Rm=T2;
```

# Deflection of upper Arm

```
%Deflection Constants
I3=(pi*d3^4)/64;
I4=(pi*d4^4)/64;
L1=l3/2;
L2=l3+l4/2;

clear x
```

```
x=linspace(0,l3+l4,100);
y1=zeros(length(x),1);
y2=zeros(length(x),1);
for i=1:length(x)
    if x(i)<l3
        I=I3;
    else
        I=I4;
    end

    %deflection due to load 1
    if x(i)<L1
        y1(i)=((m3*g*x(i)^2)/(6*E*I))*(x(i)-3*L1);
    else
        y1(i)=((m3*g*L1^2)/(6*E*I))*(L1-3*x(i));
    end

    %deflection due to load 2
    if x(i)<L2
        y2(i)=((m4*g*x(i)^2)/(6*E*I))*(x(i)-3*L2);
    else
        y2(i)=((m4*g*L2^2)/(6*E*I))*(L2-3*x(i));
    end

end


%Superposition of loads
y=y1+y2;
maxdef=min(y)
%plotting Deflection of links 3 and 4
figure
plot(x,y)
title('Deflection of links 3 and 4')
xlabel('Length of Beam (m)')
ylabel('Deflection of Beam (m)')



return
```

```
maxdef =

   -0.0075
```



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