University of Technology
الجامعة التكنولوجية

Computer Science Department
قسم علوم الحاسوب

المرئية الافتراضية\عملي

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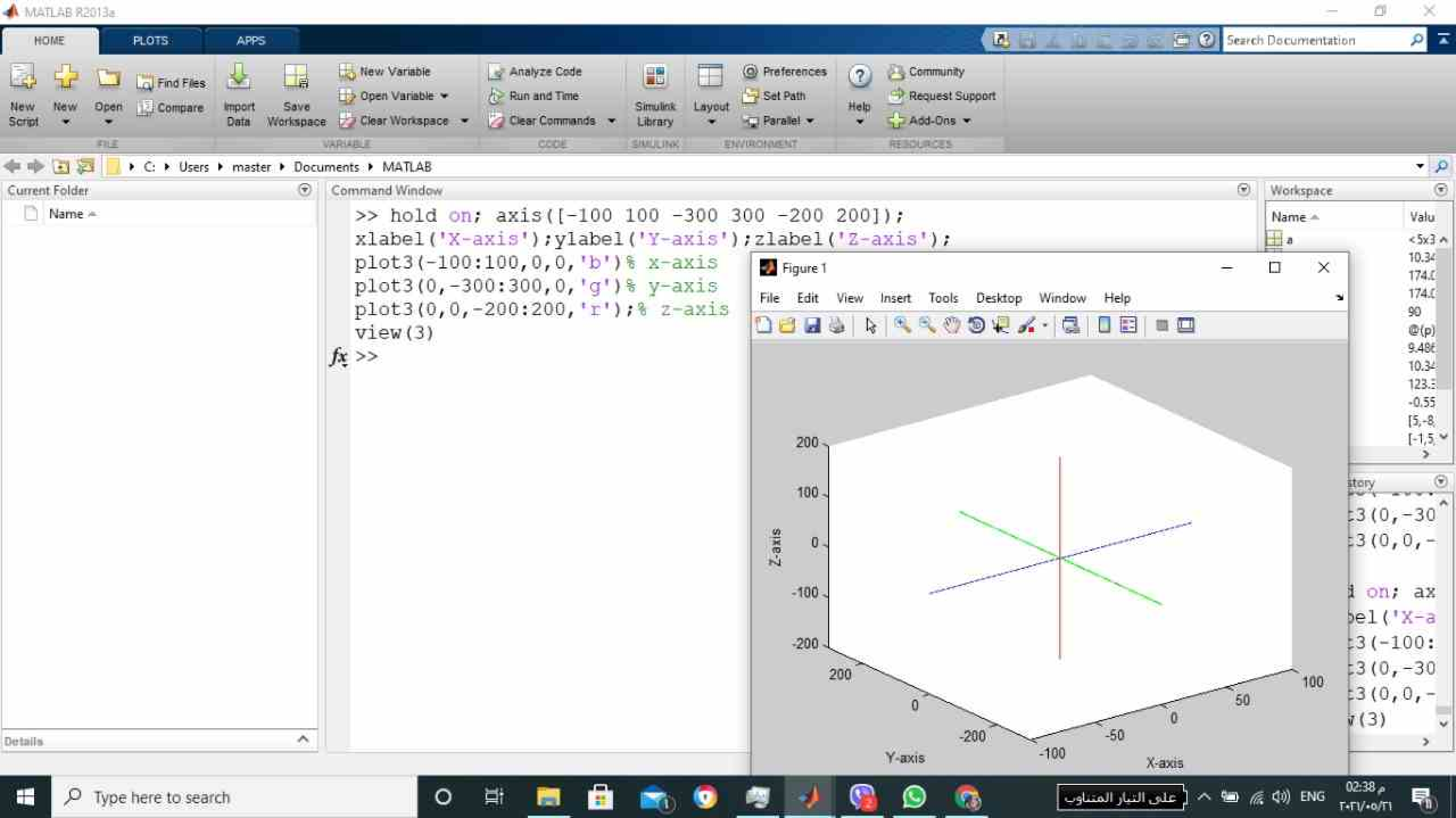
MATLAB R2013a
HOME
PLOTS
APPS
Search Documentation
New Script
New
Open
Find Files
Compare
Import Data
Save Workspace
New Variable
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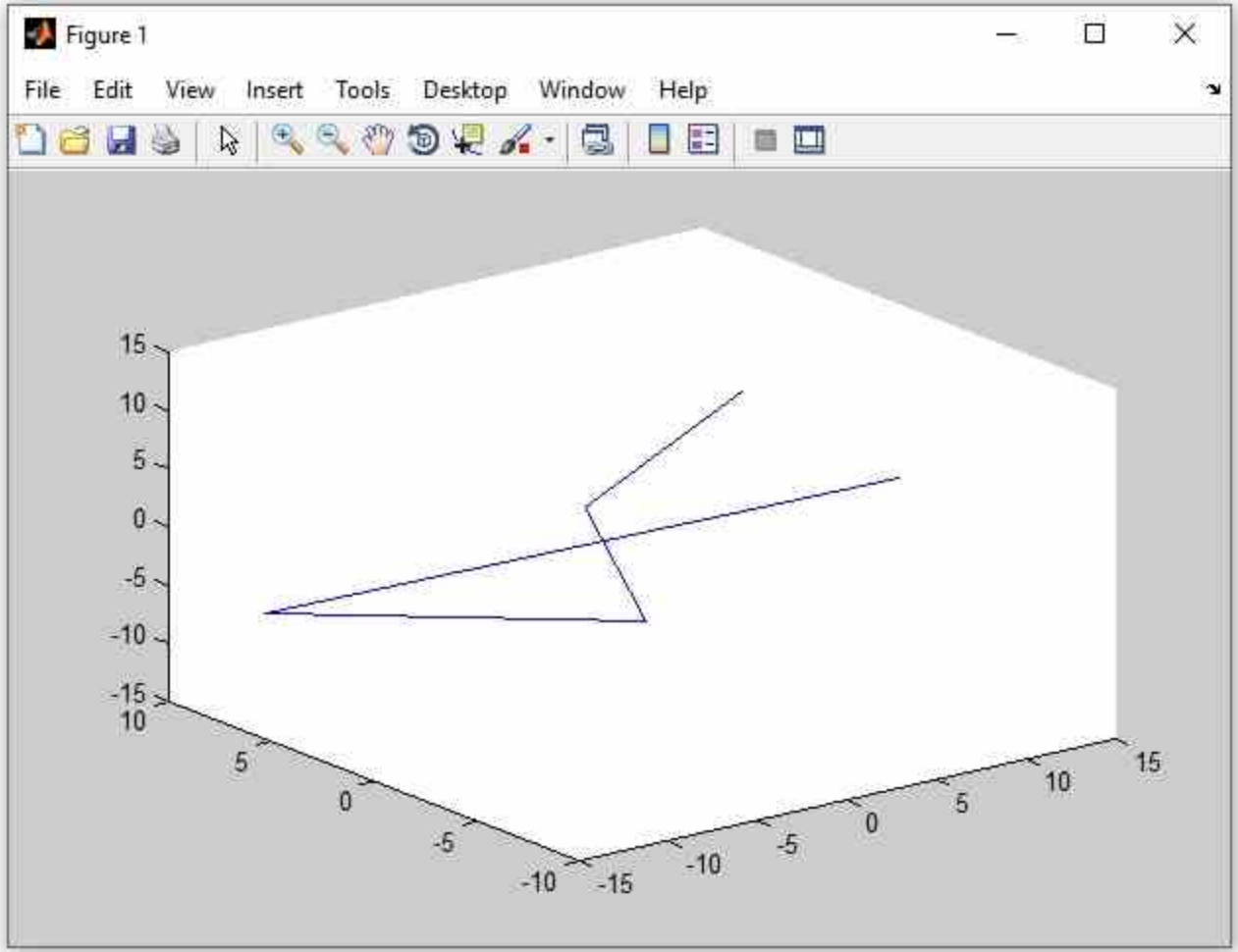
C: ▸ Users ▸ master ▸ Documents ▸ MATLAB
Current Folder
Name
Details
Command Window
>> hold on; axis([-100 100 -300 300 -200 200]);
xlabel('X-axis');ylabel('Y-axis');zlabel('Z-axis');
plot3(-100:100,0,0,'b')% x-axis
plot3(0,-300:300,0,'g')% y-axis
plot3(0,0,-200:200,'r');% z-axis
view(3)
fx >>
Workspace
Figure 1
File Edit View Insert Tools Desktop Window Help
Z-axis
Y-axis
X-axis
200
100
0
-100
-200
200
0
-200
100
50
0
-50
-100
Type here to search
ENG
02:38

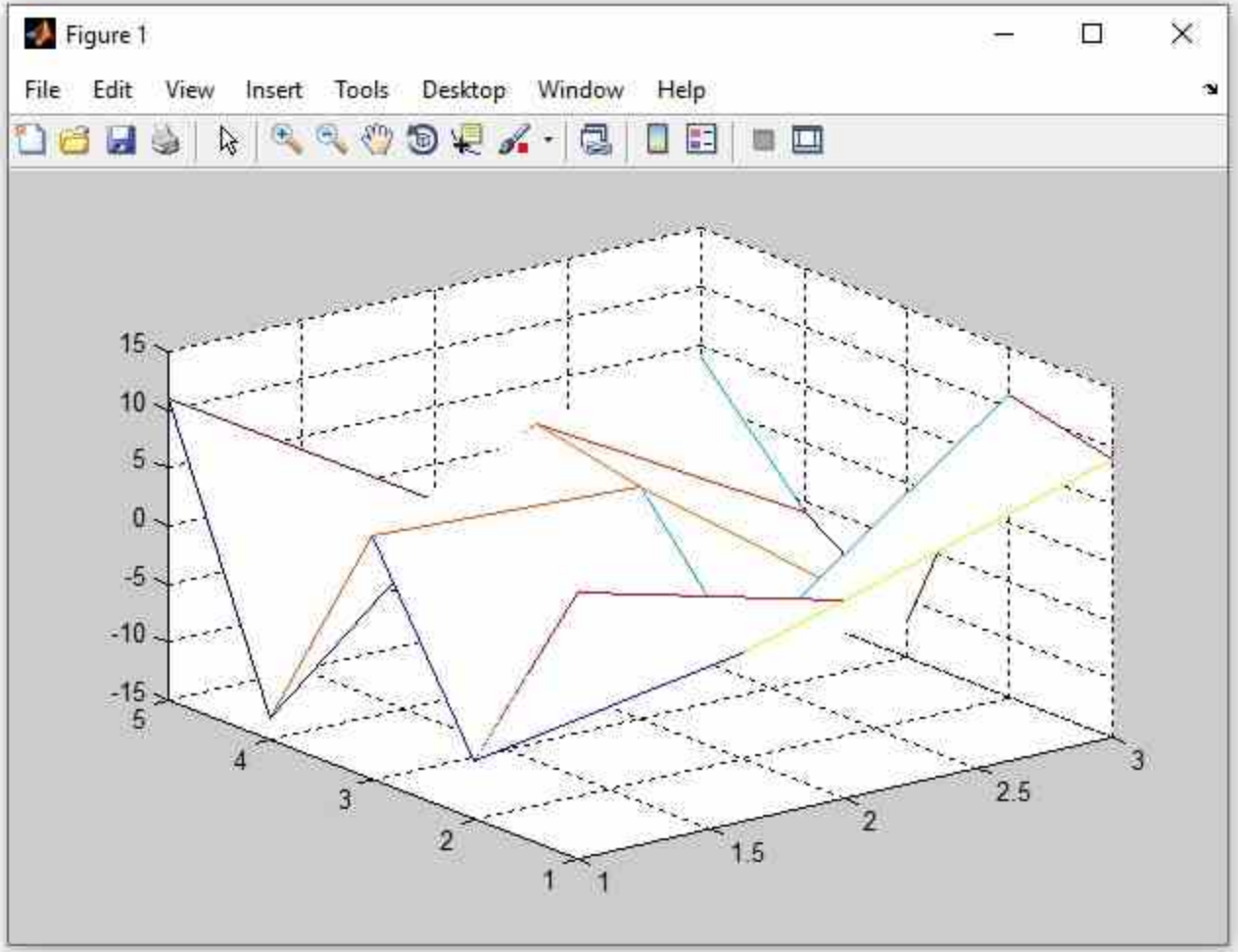
Command Window

```
>> a=[8 2 9;-10 -6 11;6 5 -12;-13 7 -6;11 -3 4]

a =

     8     2     9
   -10    -6    11
     6     5   -12
   -13     7    -6
    11    -3     4

>> plot3(a(:,1),a(:,2),a(:,3))
>>
```



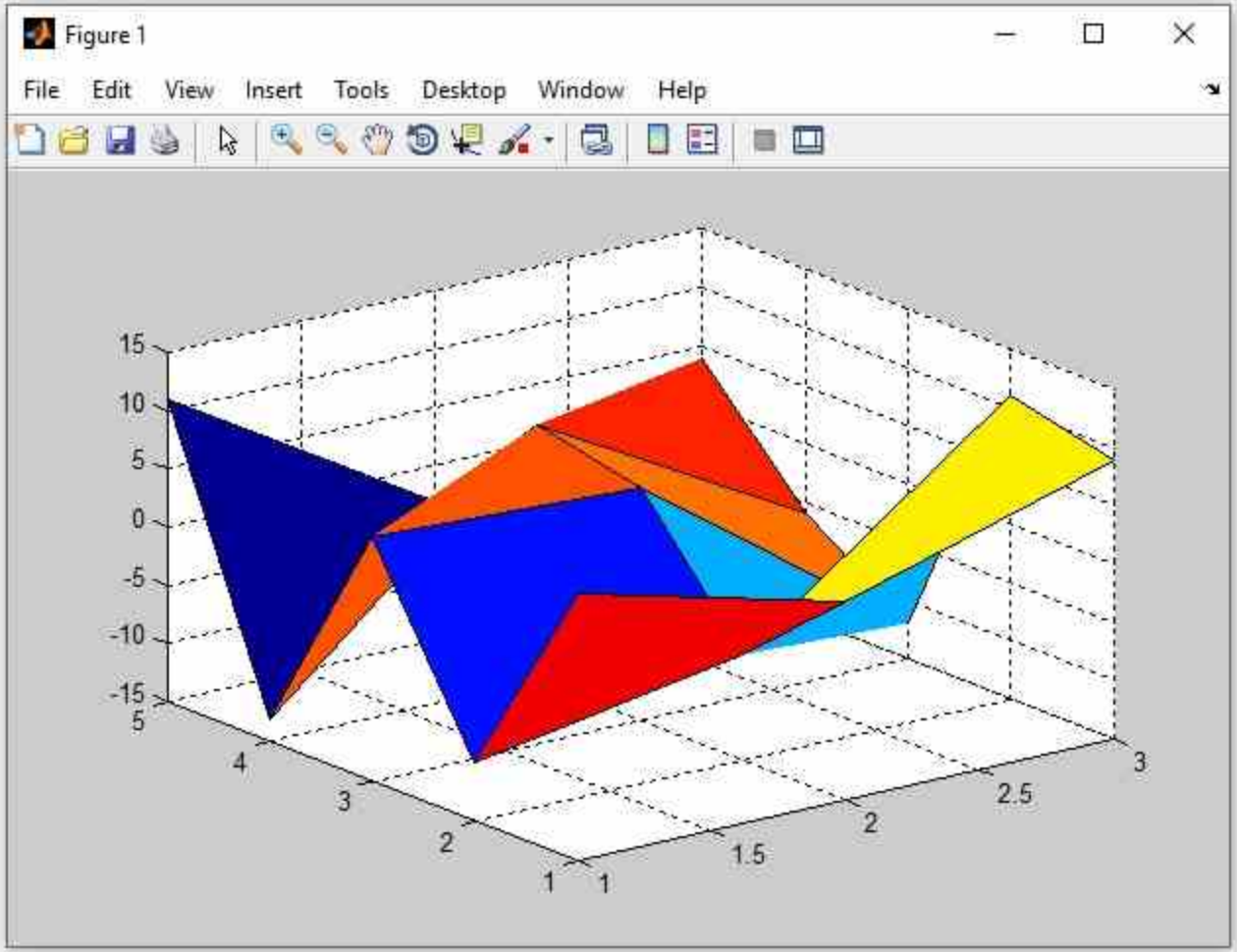
Command Window

```
>> a

a =

     8     2     9
   -10    -6    11
     6     5   -12
   -13     7    -6
    11    -3     4

>> mesh(a)
>>
```



Command Window

```
>> a

a =

     8     2     9
   -10    -6    11
     6     5   -12
   -13     7    -6
    11    -3     4

>> surf(a)
>>
```



Command Window

```
>> v=[5 -8 1],w=[-1,5,-9]

v =

     5    -8     1


w =

    -1     5    -9

>> w+v

ans =

     4    -3    -8

>> w+v==v+w

ans =

     1     1     1

>>
```

Command Window

```
>> v=[5 -8 1],w=[-1,5,-9]

v =

     5    -8     1


w =

    -1     5    -9

>> v-w

ans =

     6   -13    10

>> v-w==w-v

ans =

     0     0     0

fx >>
```

Command Window

```
>> v=[5 -8 1],w=[-1,5,-9]

v =

     5    -8     1


w =

    -1     5    -9

>> dot(w,v)

ans =

   -54

>> dot(w,v)==dot(v,w)

ans =

     1

fx >>
```

Command Window

```
>> v=[5 -8 1],w=[-1,5,-9]

v =

     5    -8     1


w =

    -1     5    -9

>> cross(v,w)

ans =

    67    44    17

>> cross(v,w)==cross(w,v)

ans =

     0     0     0

fx >>
```

Command Window

```
>> w,mw=modules(w)

w =

    -1     5    -9

mw =

   10.3441

>> ax=acosd(w(1)/mw),ay=acosd(w(2)/mw),az=acosd(w(3)/mw)

ax =

   95.5477

ay =

   61.0944

az =

  150.4659
```

Command Window

```
>> w,mw=modules(w)

w =

    -1     5    -9

mw =

   10.3441

>> ax=acosd(w(1)/mw),ay=acosd(w(2)/mw),az=acosd(w(3)/mw)

ax =

   95.5477

ay =

   61.0944

az =

  150.4659
```

Command Window

```
v =

     5     -8      1


w =

    -1      5     -9

>> wv=dot(w,v),mw=modules(w),mv=modules(v)

wv =

    -54

mw =

   10.3441


mv =

    9.4868

>> acosd(wv/(mw*mv))
```

w.v=|w|*|v|*cos(f)==>cos(f)= w.v / (|w|*|v|)

f=Invese Cosine [w.v/ (|w|*|v|)

Command Window

```
>> a

a =

     8     2     9
   -10    -6    11
     6     5   -12
   -13     7    -6
    11    -3     4

>> a(:,4)=1

a =

     8     2     9     1
   -10    -6    11     1
     6     5   -12     1
   -13     7    -6     1
    11    -3     4     1

fx >>
```

Add homogneons in 3D point or 3D Matrix

That Need in 3D matrix transformations

```
show3=@(f)(plot3(f(:,1),f(:,2),f(:,3))); modules=@(p)(sum(p.^2)^0.5);

shift3=@(tx ,ty,tz)([1 0 0 0
                     0 1 0 0
                     0 0 1 0
                     tx ty tz 1]);

scale3=@(sx ,sy,sz)([sx 0 0 0
                     0 sy 0 0
                     0 0 sz 0
                     0 0 0 1]);

rotate3x=@(th)([1 0 0 0
                0 cosd(th) sind(th)  0
                0 -sind(th) cosd(th) 0
                0  0         0       1]);

rotate3y=@(th)([cosd(th) 0 sind(th) 0
                 0       1   0      0
                -sind(th) 0 cosd(th) 0
                0       0    0    1]);

rotate3z=@(th)([cosd(th) sind(th) 0 0
               -sind(th) cosd(th) 0 0
               0        0         1 0
               0        0         0 1]);
```

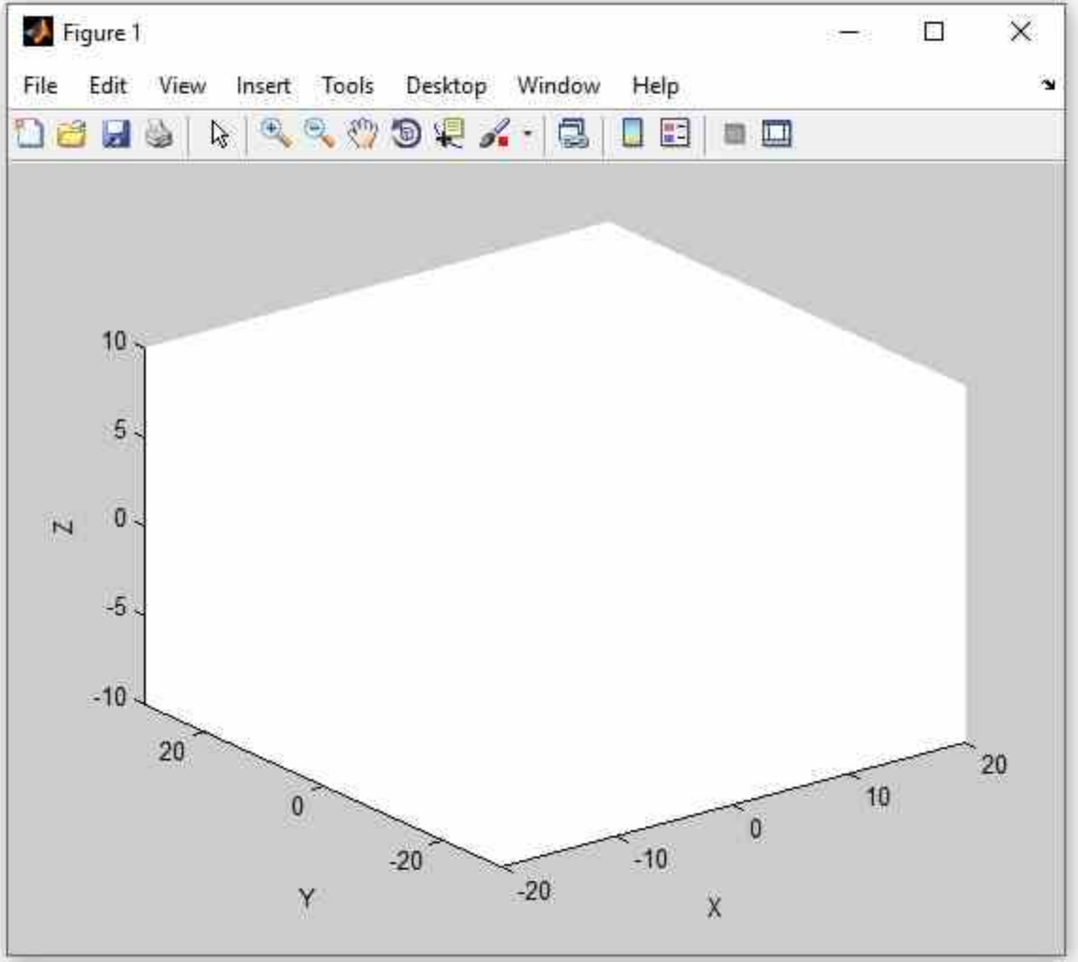
```
Mirror3o=([-1  0  0  0
           0 -1  0  0
           0  0 -1  0
           0  0  0  1]);

Mirror3x=([ 1  0  0  0
           0 -1  0  0
           0  0 -1  0
           0  0  0  1]);

Mirror3y=([-1  0  0  0
           0  1  0  0
           0  0 -1  0
           0  0  0  1]);

Mirror3z=([-1  0  0  0
           0 -1  0  0
           0  0  1  0
           0  0  0  1]);

Mirror3xy=([1  0  0  0
            0  1  0  0
            0  0 -1  0
            0  0  0  1]);

Mirror3xz=([1  0  0  0
            0 -1  0  0
            0  0  1  0
            0  0  0  1]);

Mirror3yz=([-1  0  0  0
            0  1  0  0
            0  0  1  0
            0  0  0  1]);
```

Command Window

```
>> a=[0 0 0;0 9 0;11 0 0;0 0 0;5 7 -7;0 9 0]
hold on;xlabel('X');ylabel('Y');zlabel('Z');
axis([-20 20 -30 30 -10 10]); view(3);

a =

     0     0     0
     0     9     0
    11     0     0
     0     0     0
     5     7    -7
     0     9     0

>> a(:,4)=1

a =

     0     0     0     1
     0     9     0     1
    11     0     0     1
     0     0     0     1
     5     7    -7     1
     0     9     0     1
```

Figure 1

File Edit View Insert Tools Desktop Window Help



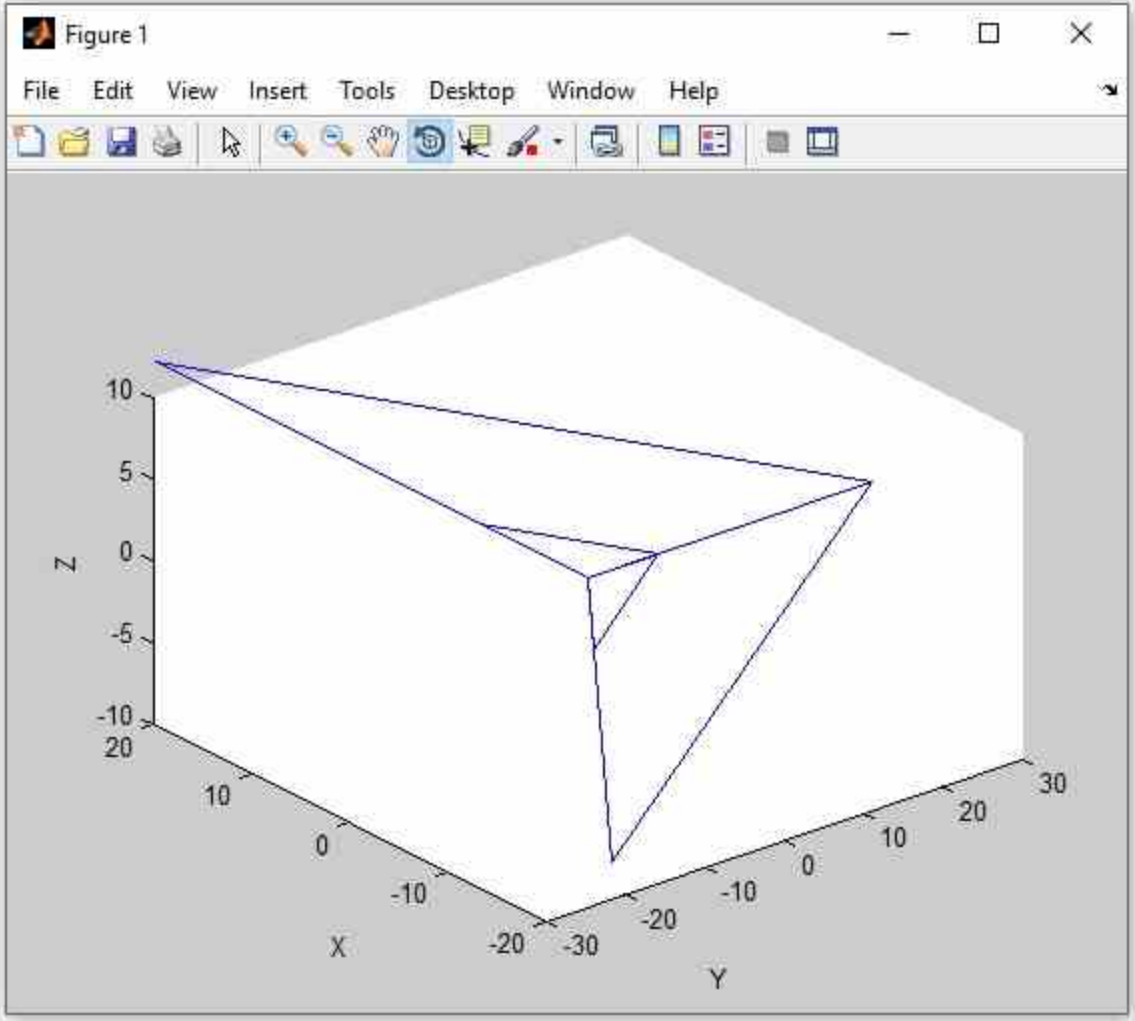
Workspace

Name	Value
Mirror3o	<4x4 double>
Mirror3x	<4x4 double>
Mirror3xy	<4x4 double>
Mirror3xz	<4x4 double>
Mirror3y	<4x4 double>
Mirror3z	<4x4 double>
a	<6x4 double>
modules	@(p)(sum(p.^2)^0.5)
rotate3x	@(th)([1,0,0,0;0,cosd(th),s
rotate3y	@(th)([cosd(th),0,sind(th)
rotate3z	@(th)([cosd(th),sind(th),0,
s	<4x4 double>
scale3	@(sx,sy,sz)([sx,0,0,0;0,sy,0
shift3	@(tx,ty,tz)([1,0,0,0;0,1,0,0;
show3	@(f)(plot3(f(:,1),f(:,2),f(:,3)

Command History

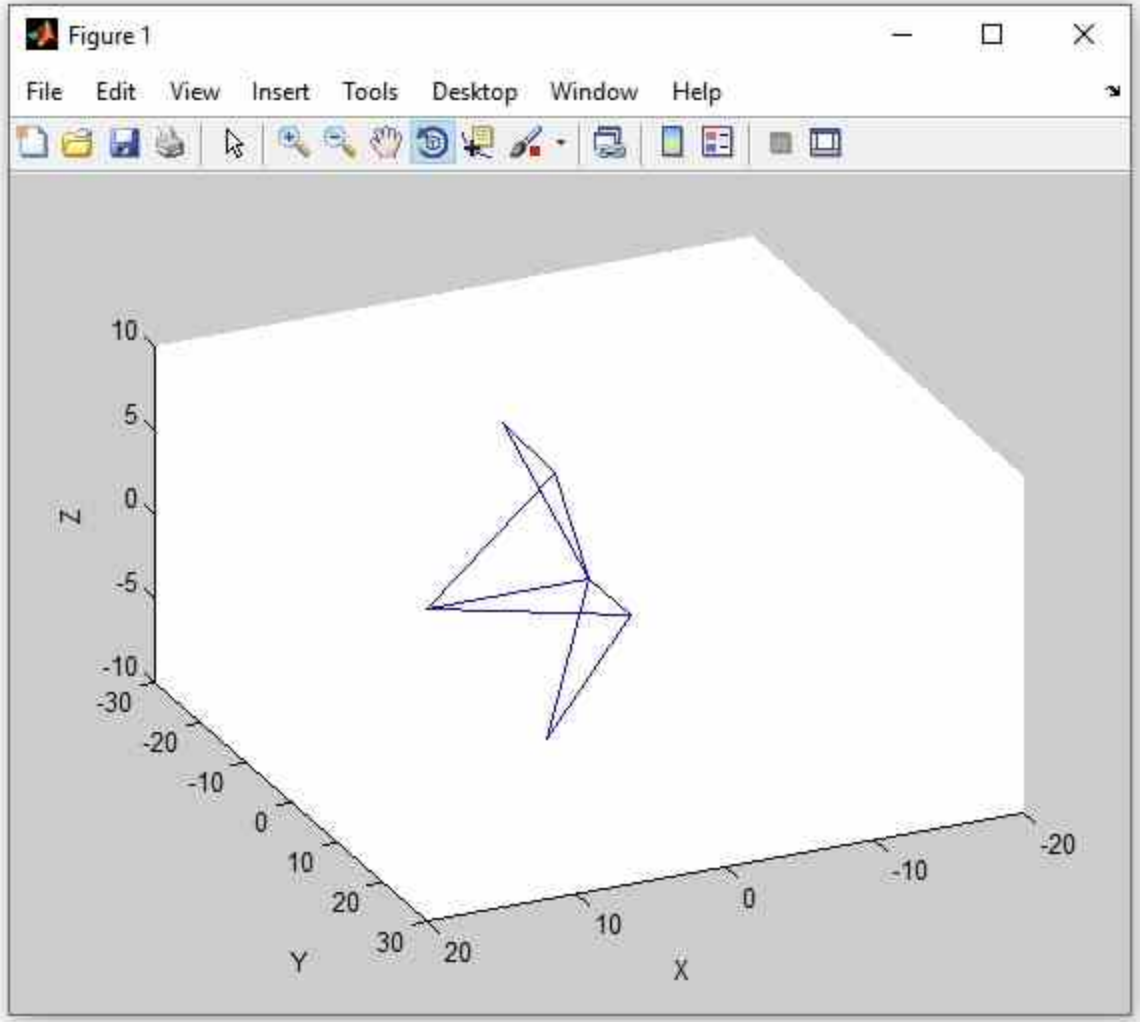
Command Window

```
>> a

a =

     0     0     0     1
     0     9     0     1
    11     0     0     1
     0     0     0     1
     5     7    -7     1
     0     9     0     1

>> s=scale3(4,4,4)

s =

     4     0     0     0
     0     4     0     0
     0     0     4     0
     0     0     0     1

>> show3(a),show3(a*s)
>>
```



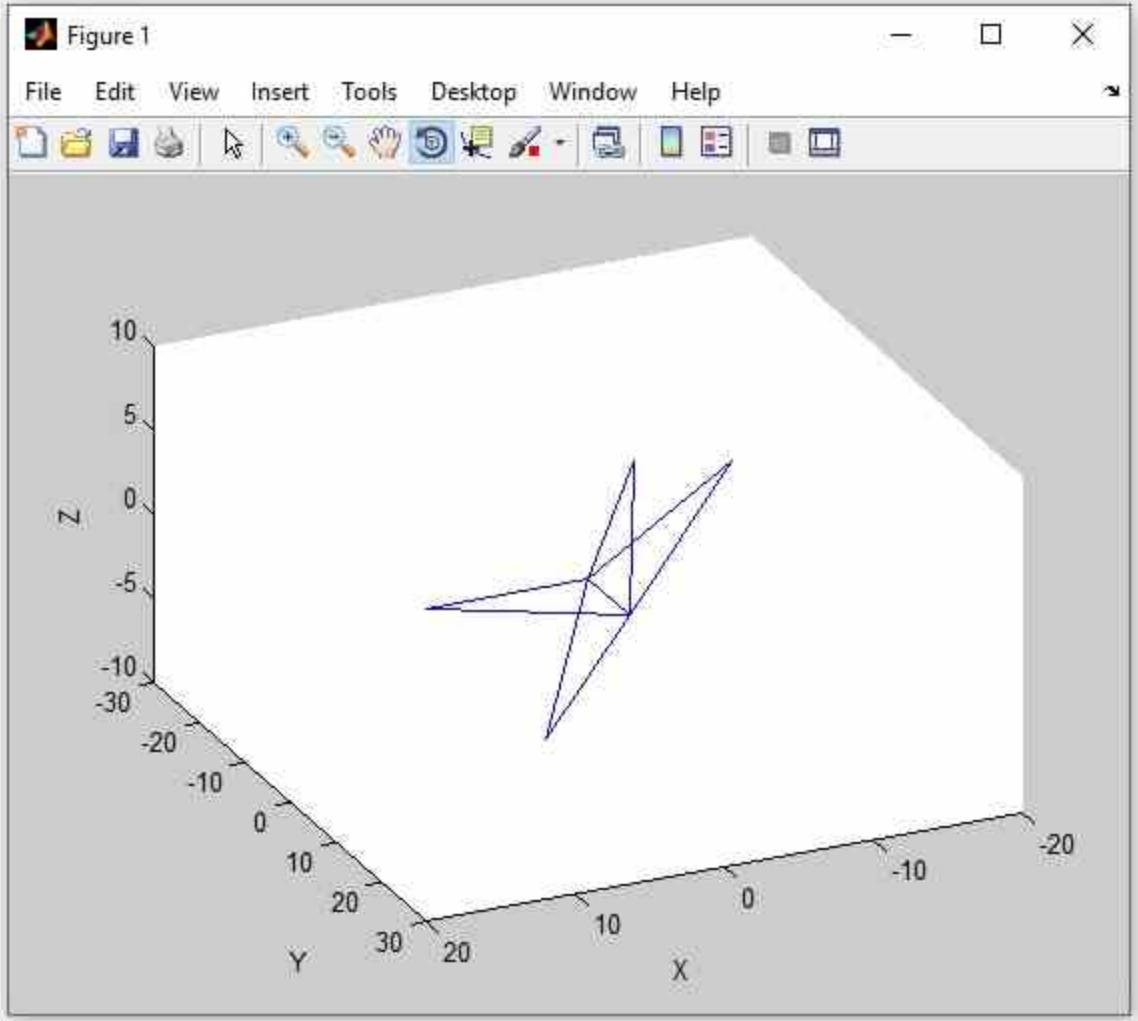
Command Window

```
>> a

a =

     0     0     0     1
     0     9     0     1
    11     0     0     1
     0     0     0     1
     5     7    -7     1
     0     9     0     1

>> rx=rotate3x(150)

rx =

    1.0000         0         0         0
         0   -0.8660    0.5000         0
         0   -0.5000   -0.8660         0
         0         0         0    1.0000

>> show3(a),show3(a*rx)
>>
```



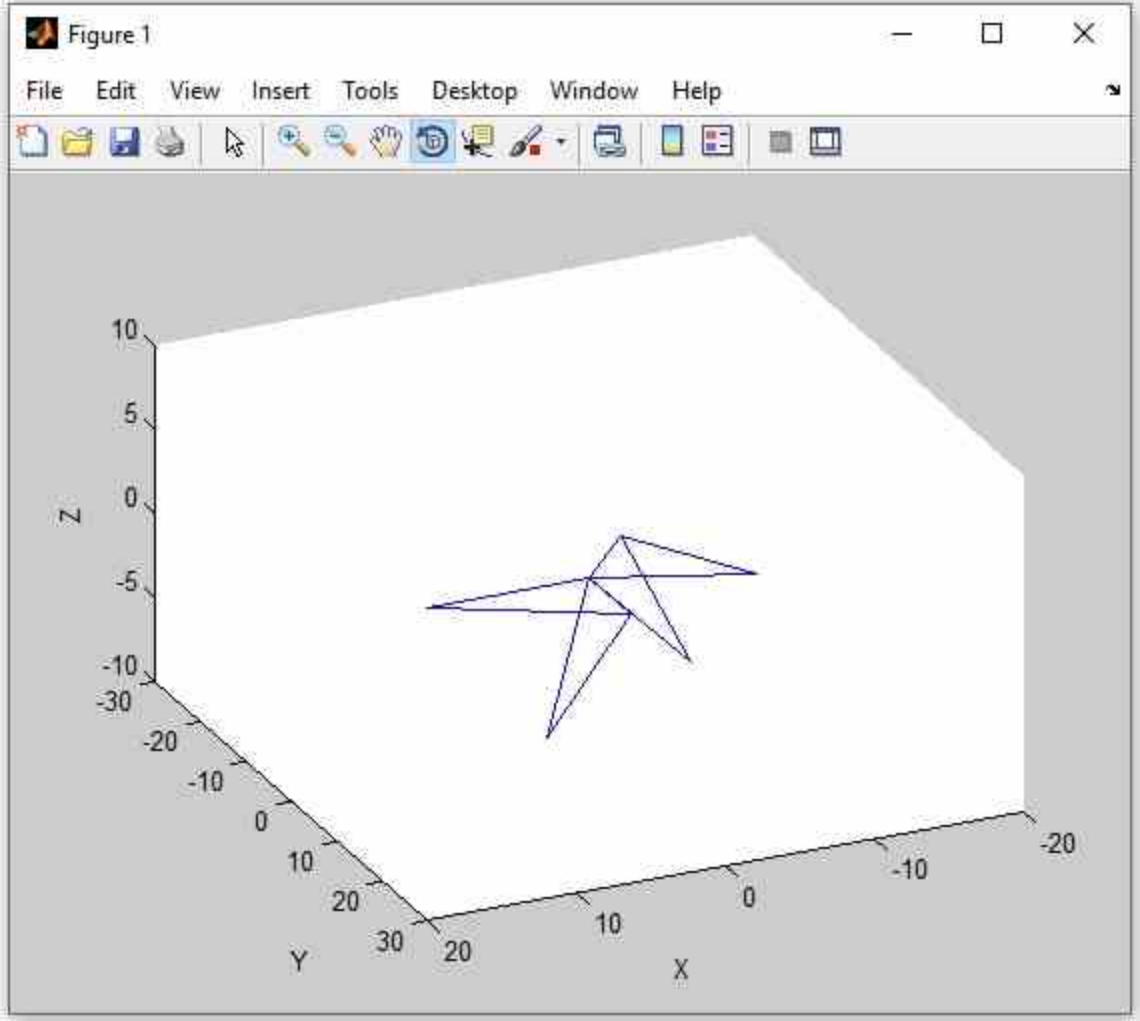
Command Window

```
>> a

a =

     0     0     0     1
     0     9     0     1
    11     0     0     1
     0     0     0     1
     5     7    -7     1
     0     9     0     1

>> ry=rotate3y(150)

ry =

   -0.8660         0    0.5000         0
         0    1.0000         0         0
   -0.5000         0   -0.8660         0
         0         0         0    1.0000

>> show3(a),show3(a*ry)
>>
```



Command Window

```
>> a

a =

     0     0     0     1
     0     9     0     1
    11     0     0     1
     0     0     0     1
     5     7    -7     1
     0     9     0     1

>> rz=rotate3z(150)

rz =

   -0.8660    0.5000         0         0
   -0.5000   -0.8660         0         0
         0         0    1.0000         0
         0         0         0    1.0000

>> show3(a),show3(a*rz)
>>
```



Command Window

```
a =

     0     0     0     1
     0     9     0     1
    11     0     0     1
     0     0     0     1
     5     7    -7     1
     0     9     0     1

>> t=shift3(9,-5,11)

t =

     1     0     0     0
     0     1     0     0
     0     0     1     0
     9    -5    11     1
```

```
>> a*t

ans =

     9    -5    11     1
     9     4    11     1
    20    -5    11     1
     9    -5    11     1
    14     2     4     1
     9     4    11     1
```

Tray
show3(a)
show3(a*t) ...what happen?

H.w// Try Mirror Transform & 3D shear Transform

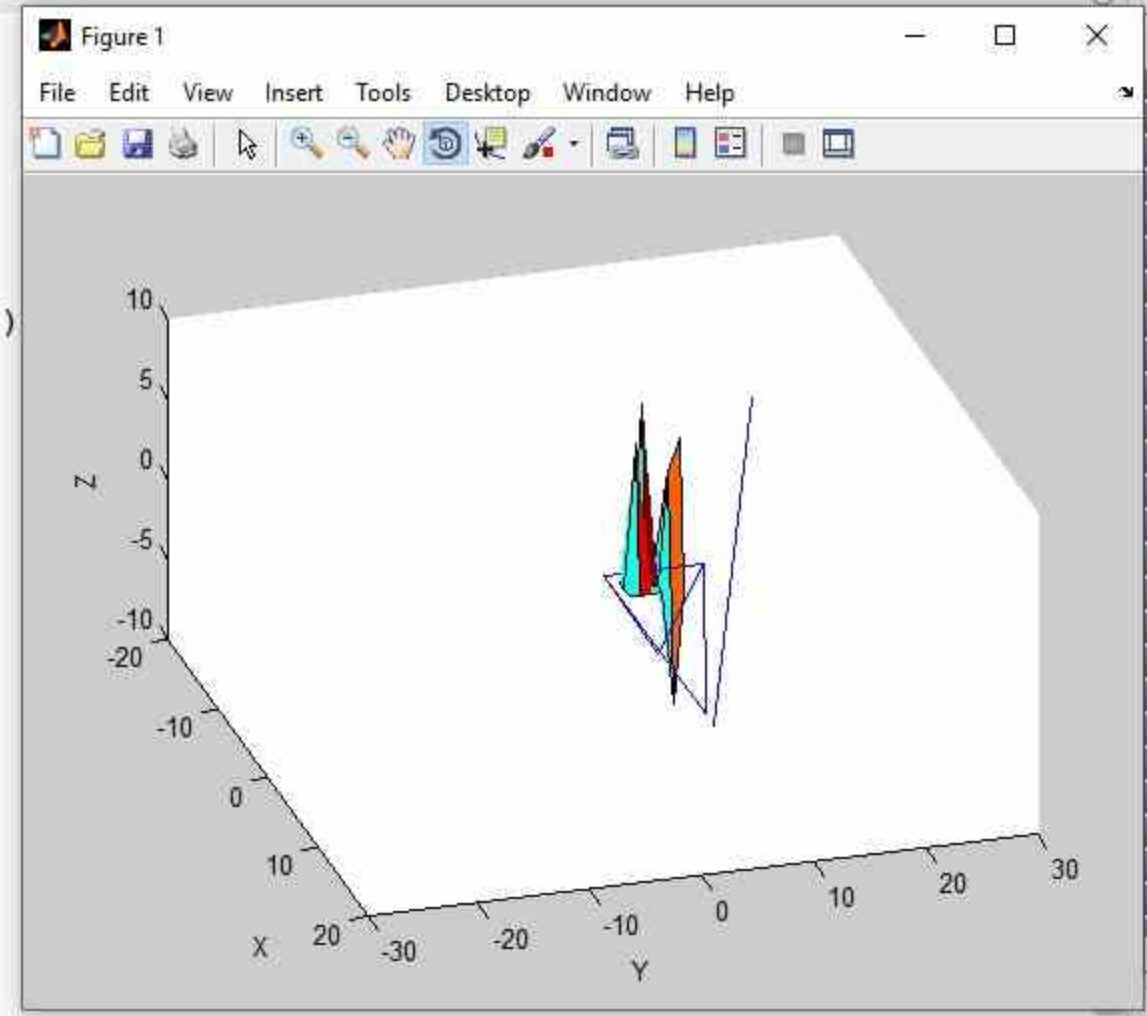
Command Window

```
>> l3=[-15,20,3;11,5,-5]

l3 =

   -15    20     3
    11     5    -5

>> show3(a),surf(a),plot3(l3(:,1),l3(:,2),l3(:,3))
>> s1=shift3(15 ,-20 ,-3)

s1 =

     1     0     0     0
     0     1     0     0
     0     0     1     0
    15   -20    -3     1

>> dl=diff(l3)

dl =

    26   -15    -8
```

Step 1

shift start line into (0, 0, 0)
==> Tx= -x1, Ty =-y1, Tz= -z1

==> dx= x2-x1, dy = y2-y1, dz= z2-z1



```
dl =

    26    -15     -8
```

==> (dx ,dy ,dz)

```
>> d=modules([-15 -8])
```

==> d=(dy^2+dz^2)^(1/2)

```
d =

    17

>> cz= -8/d,sz= -15/d

cz =
```

==> Cos= dz/d

```
   -0.4706
```

```
sz =
```

==> Sin= dy / d

```
   -0.8824
```

```
>> s2=[cz sz 0 0;-sz cz 0 0;0 0 1 0;0 0 0 1]

s2 =

   -0.4706   -0.8824         0         0
    0.8824   -0.4706         0         0
         0         0    1.0000         0
         0         0         0    1.0000
```

Command Window

```
l3 =

   -15    20     3
    11     5    -5

>> diff(l3)

ans =
    dx    dy    dz
    26   -15    -8
```

==> while d=17

```
>> d2=modules([26,d])

d2 =

   31.0644
```

```
>> cz=d/d2

cz =
```

=> **Cos = d / d2**

```
    0.5472

>> sz=26/d2

sz =
```

=> **Sin = dx / d2**

```
    0.8370
```

```
>> s3=[cz 0 sz 0;0 1 0 0;-sz 0 cz 0;0 0 0 1]

s3 =

    0.5472         0    0.8370         0
         0    1.0000         0         0
   -0.8370         0    0.5472         0
         0         0         0    1.0000
```

Command Window

```
s4 =

[  cos(th), sin(th), 0, 0]
[ -sin(th), cos(th), 0, 0]
[        0,       0, 1, 0]
[        0,       0, 0, 1]
```

==>Rotate about (th) in quation

```
s5 =

    0.5473         0   -0.8370         0
         0    1.0000         0         0
    0.8370         0    0.5473         0
         0         0         0    1.0000
```

==>Reverse Step3

```
s6 =

   -0.4706    0.8824         0         0
   -0.8824   -0.4706         0         0
         0         0    1.0000         0
         0         0         0    1.0000
```

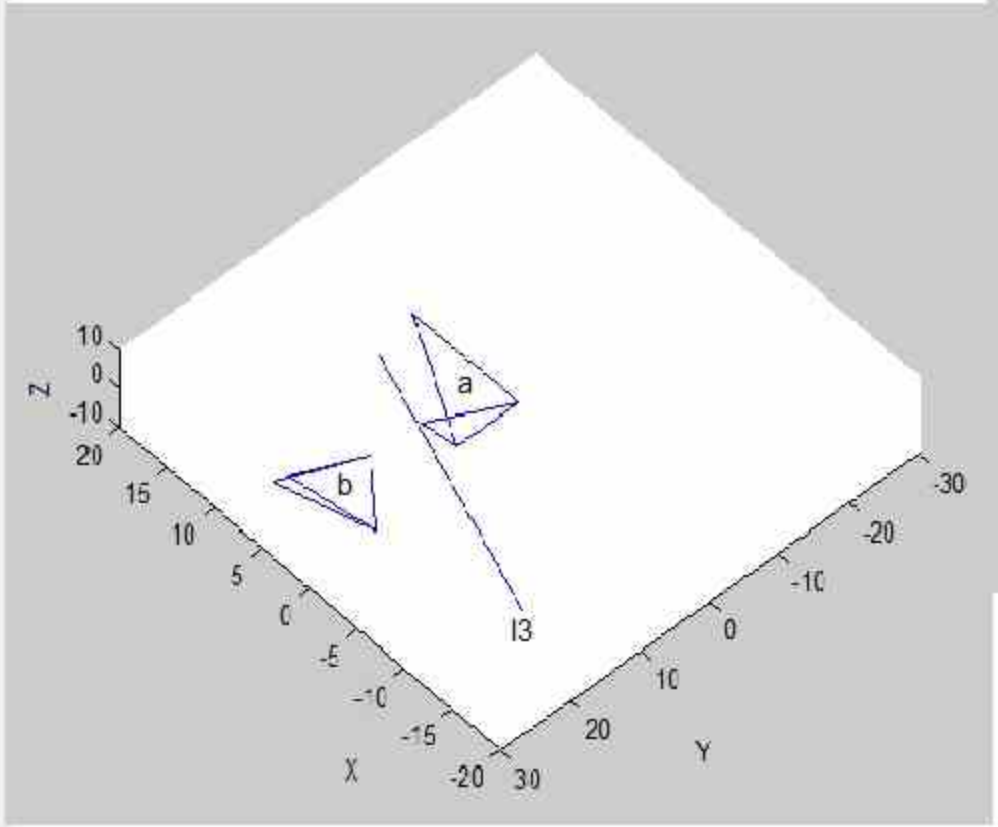
==> Reverse Step2

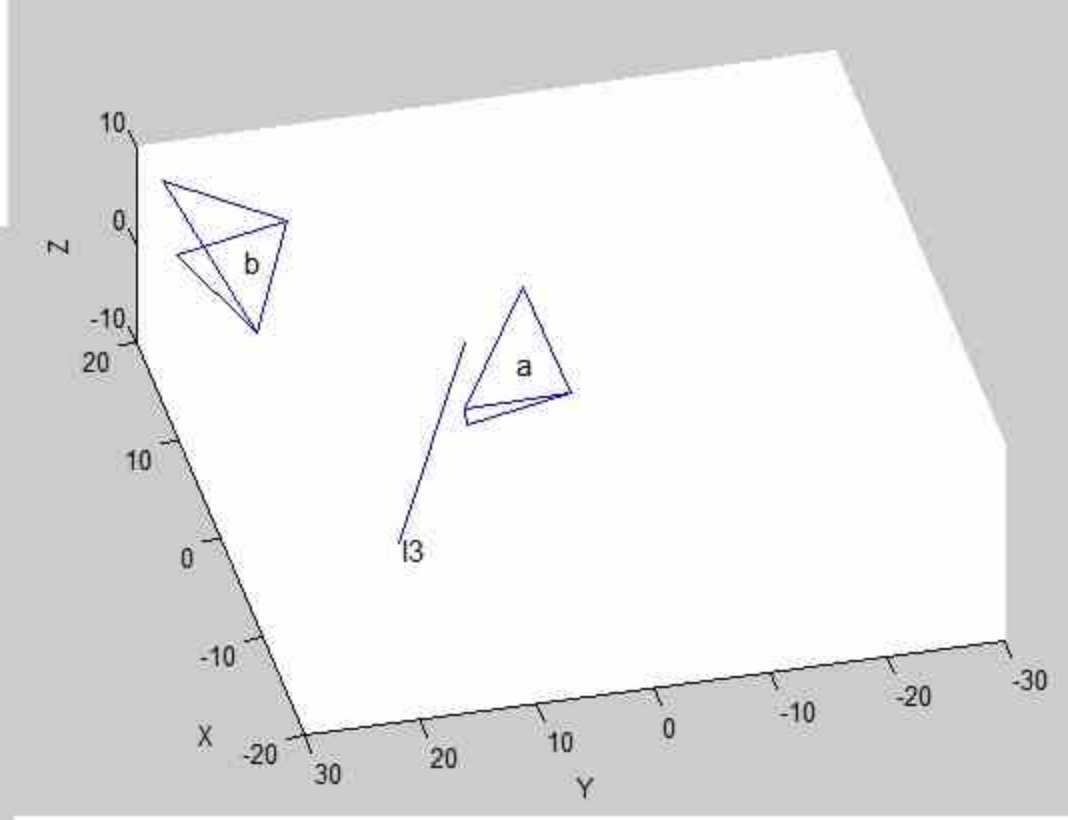
```
s7 =

     1     0     0     0
     0     1     0     0
     0     0     1     0
   -15    20     3     1
```

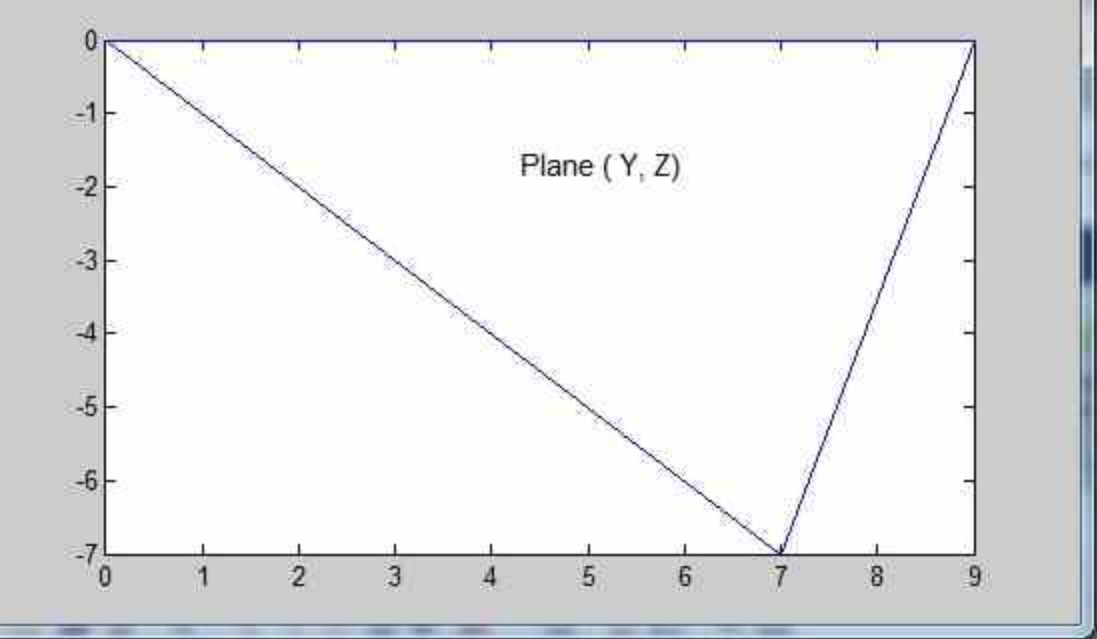
==> Reverse Step1

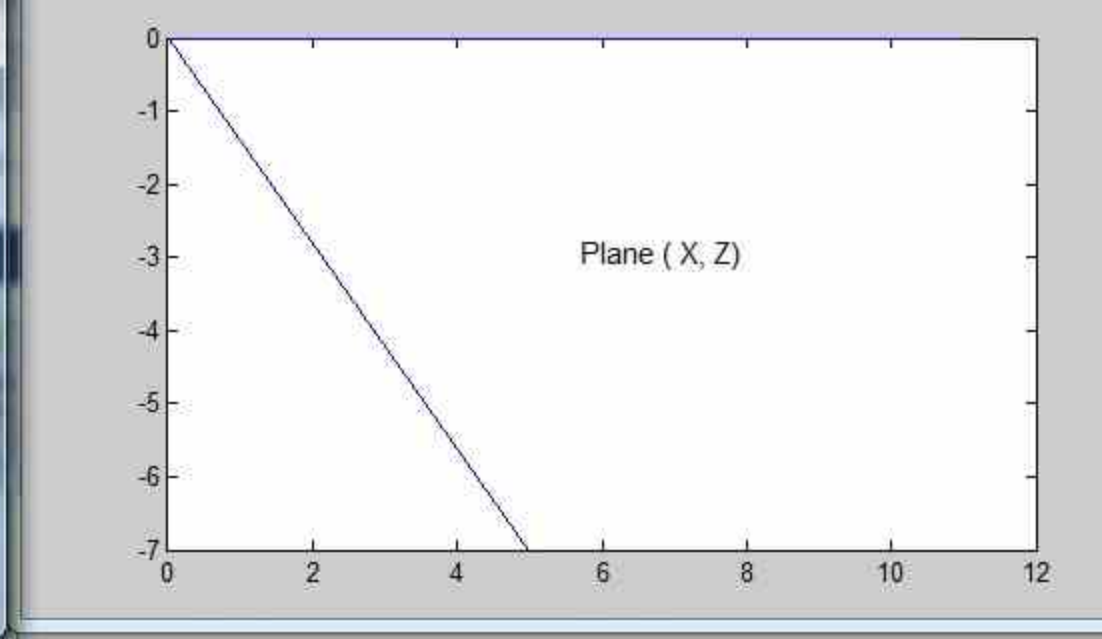
Command Window

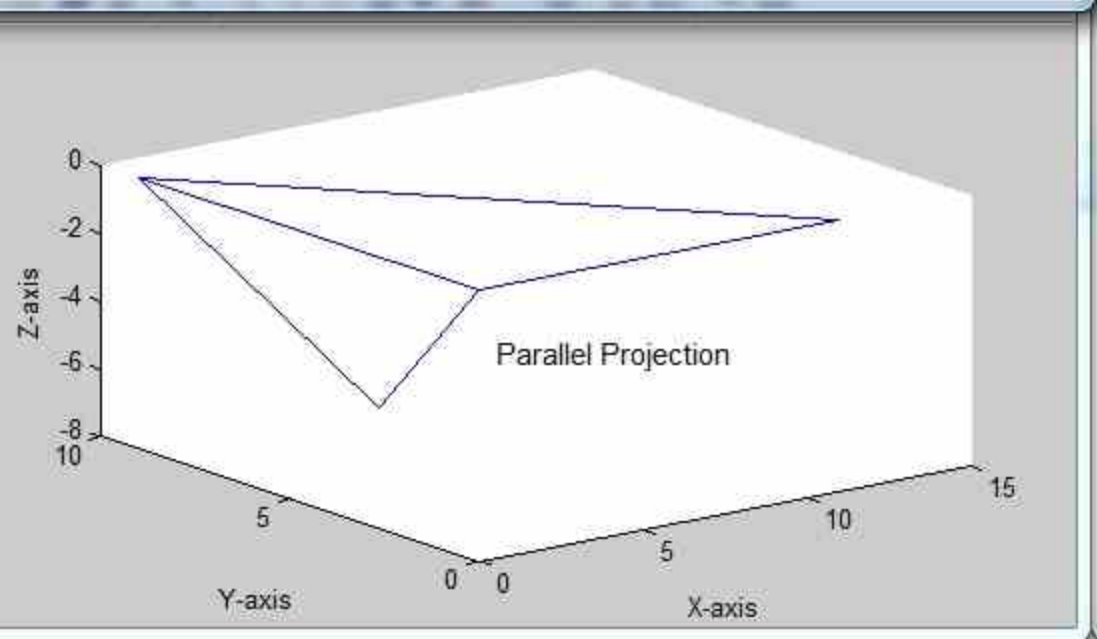
```
>> plot3(l3(:,1),l3(:,2),l3(:,3))
   plot3(a(:,1),a(:,2),a(:,3))
   b=a*s1*s2*s3*s4*s5*s6*s7
   plot3(b(:,1),b(:,2),b(:,3))
```

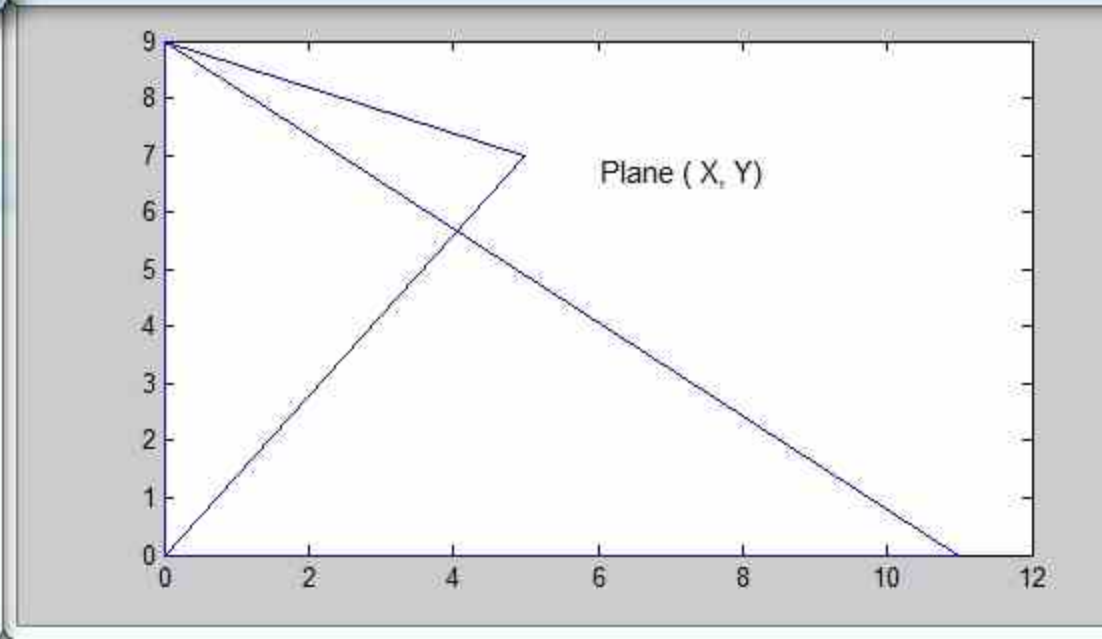





Plane (Y, Z)
0
-1
-2
-3
-4
-5
-6
-7
0 1 2 3 4 5 6 7 8 9


Plane (X, Z)
0
-1
-2
-3
-4
-5
-6
-7
0 2 4 6 8 10 12


Parallel Projection
Z-axis
0
-2
-4
-6
-8
10
5
0
Y-axis
0
5
10
15
X-axis


Plane (X, Y)
9
8
7
6
5
4
3
2
1
0
0 2 4 6 8 10 12

Command Window

```
a =
```

b= [Xi+Ux*xP , Yi+Ux*yP , Zi+Ux*zP

```
     0     0     0
     0     9     0
    11     0     0
     0     0     0
     5     7    -7
     0     9     0
```

```
bx =
```

3D represent

```
     0          0          0
     0     9.0000          0
     0    19.8000    24.2000
     0          0          0
     0    16.0000     4.0000
     0     9.0000          0
```

```
dop =
```

===> (xP, yP, zP)

```
    -5     9    11
```

```
ux =
```

===> Ux= -Xi / xP

```
         0
         0
    2.2000
         0
    1.0000
         0
```

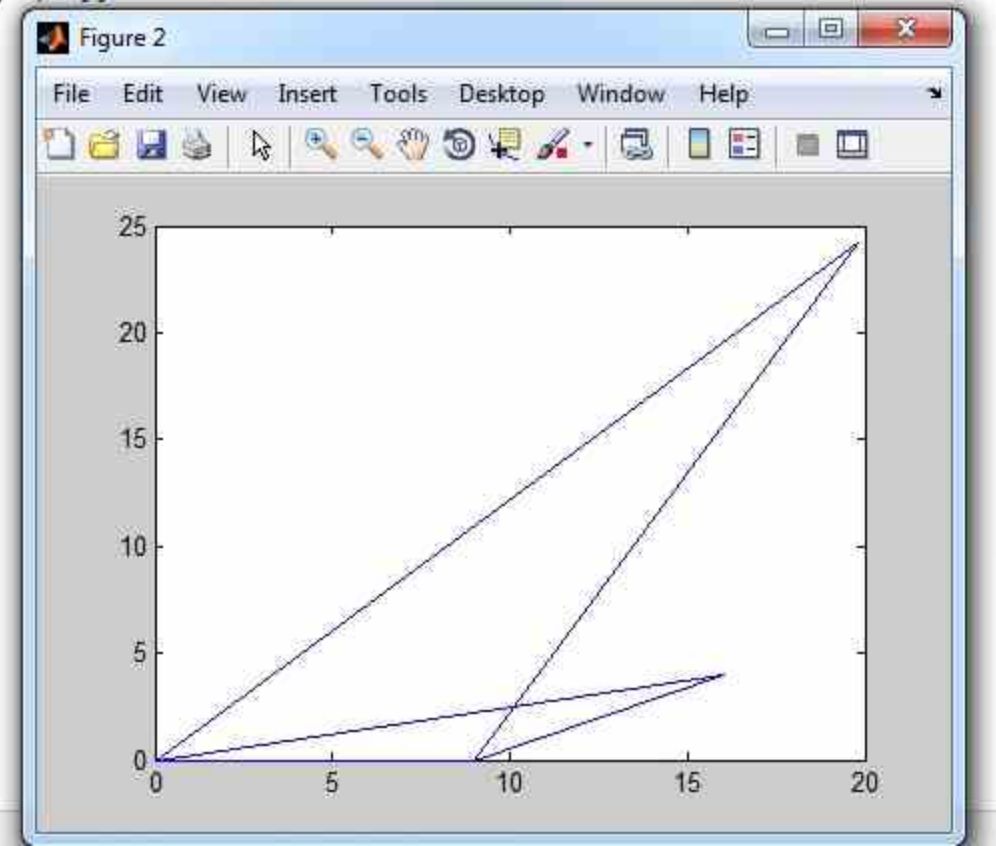
```
bx =
```

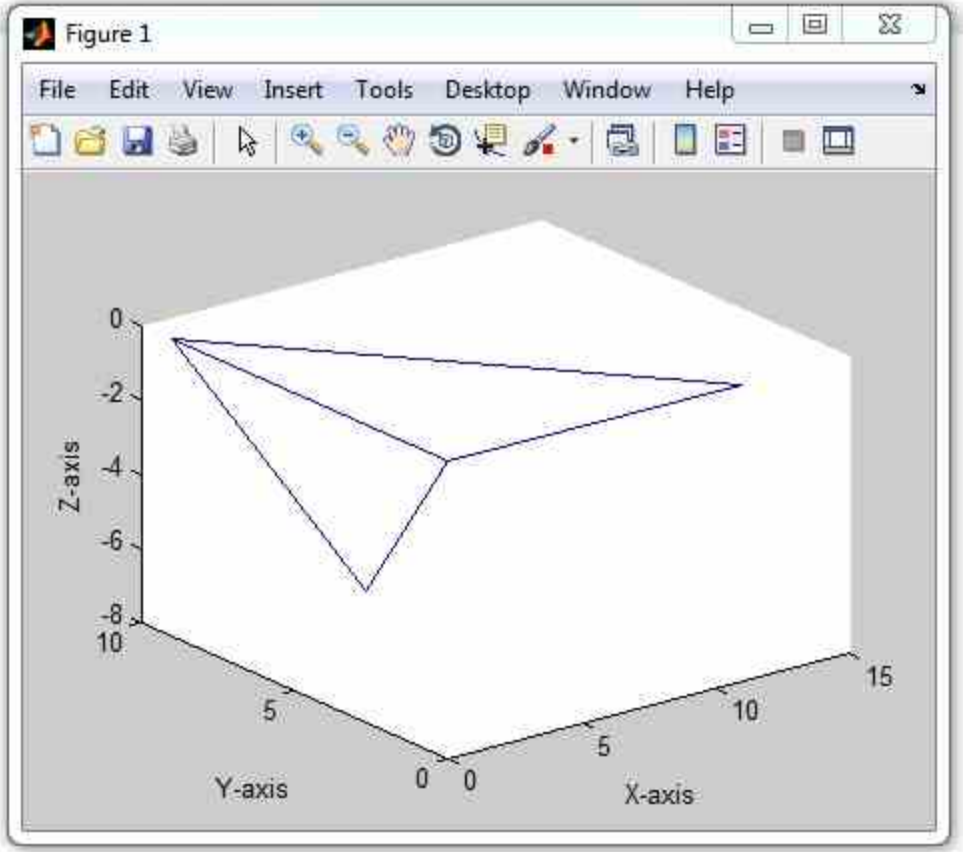
2D reprsent

```
         0          0
    9.0000          0
   19.8000    24.2000
         0          0
   16.0000     4.0000
    9.0000          0
```

Command Window

```
>> a= [0 0 0; 0 9 0; 11 0 0; 0 0 0; 5 7 -7; 0 9 0]
dop=[ -5 9  11]
% Projection-->X_axis
 ux= -a(:,1)/dop(1)
 bx=[a(:,1)+ux*dop(1),a(:,2)+ux*dop(2),a(:,3)+ux*dop(3)]
 bx(:,1)=[]
```





a =

0	0	0
0	9	0
11	0	0
0	0	0
5	7	-7
0	9	0

===>>

dop =

-5	9	11
xP	yP	zP

uy = ==> Uyi= -Yi / yp

0
-1.0000
0
0
-0.7778
-1.0000

by = [Xi + Uyi * xP , Yi + Uyi * yP , Zi + Uyi * zP]

0	0	0
5.0000	0	-11.0000
11.0000	0	0
0	0	0
8.8889	0	-15.5556
5.0000	0	-11.0000

========>>>

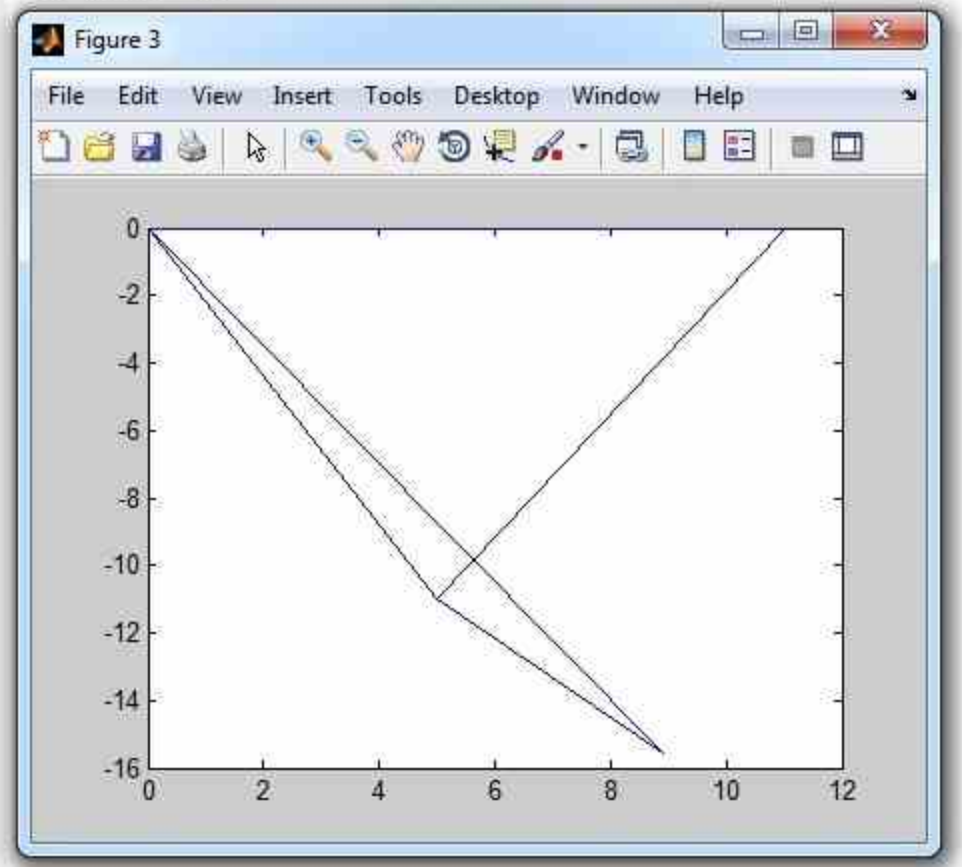
by =

0	0
5.0000	-11.0000
11.0000	0
0	0
8.8889	-15.5556
5.0000	-11.0000

Projection Y-axis

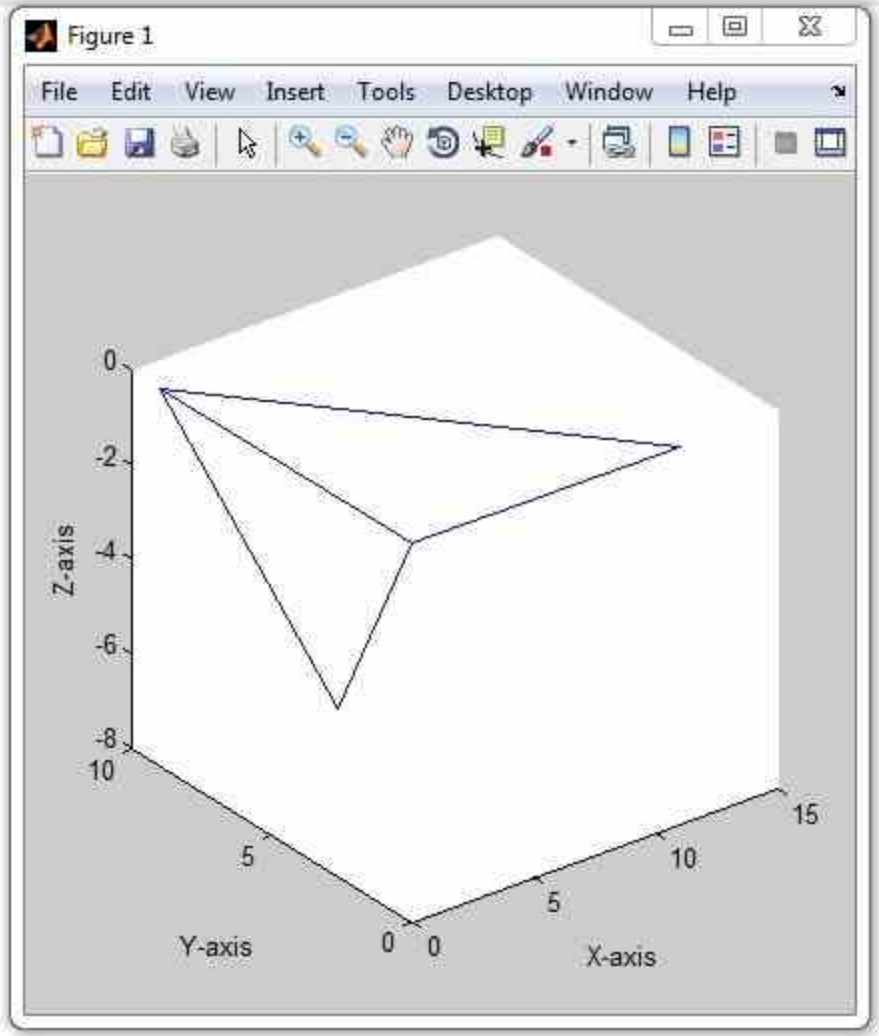
Command Window

```
>> % Projection-->Y_axis
   uy= -a(:,2)/dop(2)
   by=[a(:,1)+uy*dop(1),a(:,2)+uy*dop(2),a(:,3)+uy*dop(3)]
   by(:,2)=[]
```



Projection-Y

<<=======



```
a =

     0     0     0
     0     9     0
    11     0     0
     0     0     0
     5     7    -7
     0     9     0
```

```
dop =
    xP      yP      zP
    -5       9      11
```

uz = **==> Uiz= -Zi / zP**

```
         0
         0
         0
         0
    0.6364
         0
```

bz = **[Xi + Uiz * xP , Yi + Uiz * yP , Zi + Uiz * zP]**

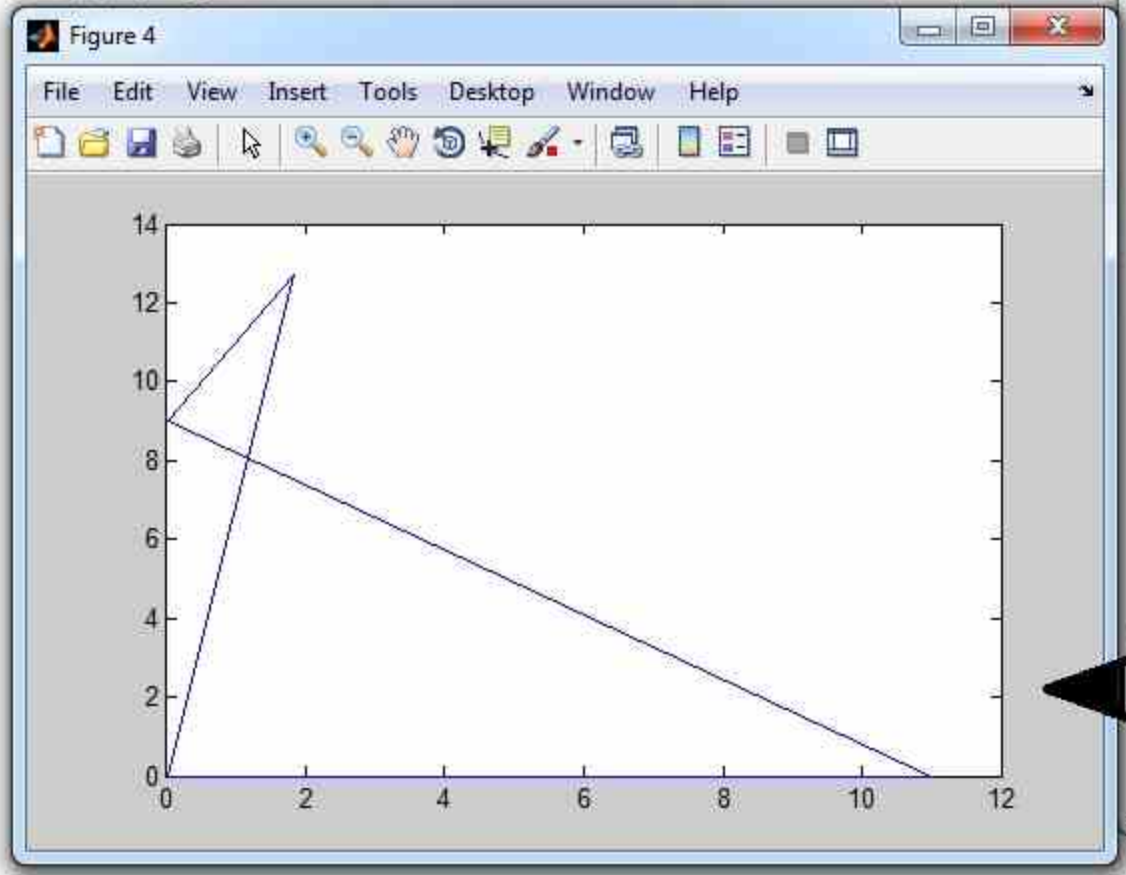
```
         0         0         0
         0    9.0000         0
   11.0000         0         0
         0         0         0
    1.8182   12.7273         0
         0    9.0000         0
```

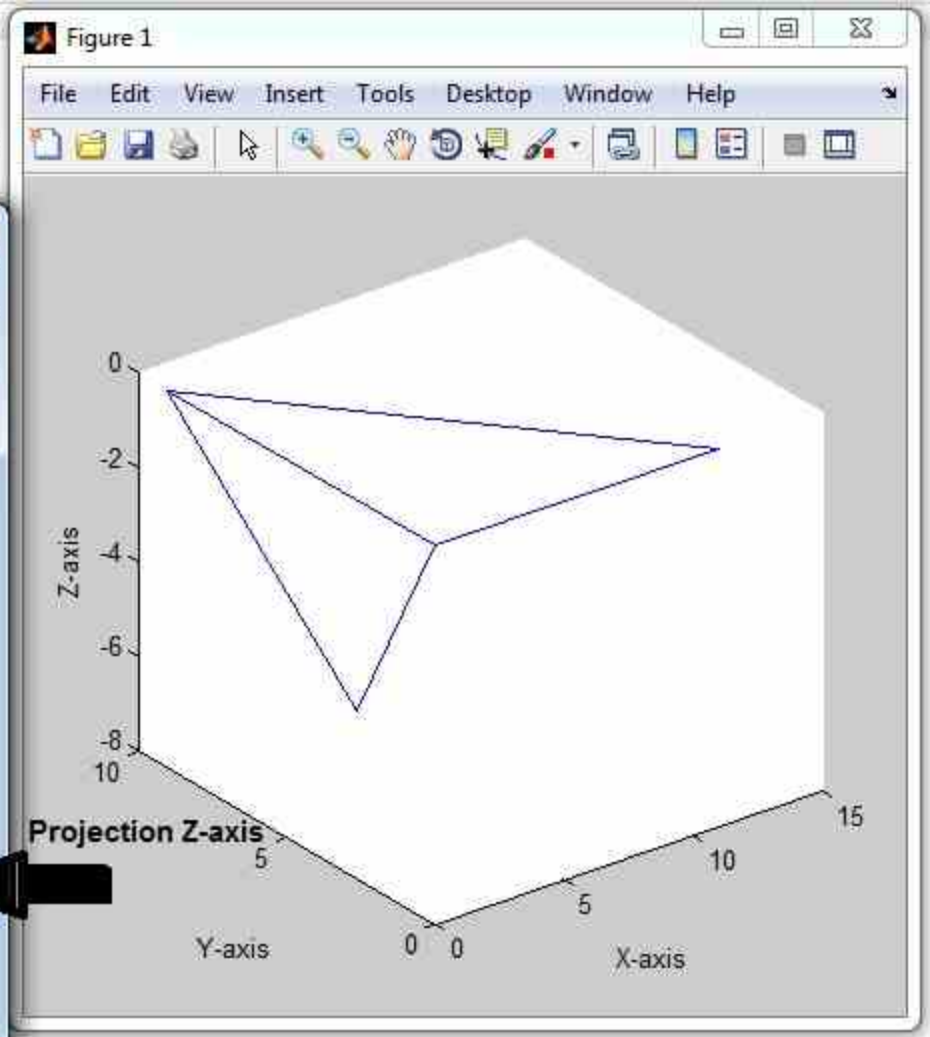
Finally, Projection-Z_axis

```
bz =

         0         0
         0    9.0000
   11.0000         0
         0         0
    1.8182   12.7273
         0    9.0000
```

Command Window

```
>> % Projection-->Z_axis
uz= -a(:,3)/dop(3)
bz=[a(:,1)+uz*dop(1),a(:,2)+uz*dop(2),a(:,3)+uz*dop(3)]
bz(:,3)=[]
```





MATLAB R2013a

```
>> clear all clc
```

f=[-5 8 0;7 -9 11;1 4 -6] , cop = [-3, 2, -7]

```
df=[f(:,1)-cop(1),f(:,2)-cop(2),f(:,3)-cop(3)]

% Projection X-axis
hx=f;
for i=1 :length(df)
ux= -cop(1)/df(i,1)
hx(i,1)=df(i,1)*ux+cop(1);
hx(i,2)=df(i,2)*ux+cop(2);
hx(i,3)=df(i,3)*ux+cop(3);
end
hx(:,1)=[]

% Projection Y-axis
hy=f;
for i=1 :length(df)
uy= -cop(2)/df(i,2)
hy(i,1)=df(i,1)*uy+cop(1);
hy(i,2)=df(i,2)*uy+cop(2);
hy(i,3)=df(i,3)*uy+cop(3);
end
hy(:,2)=[]
```

```
>> % Projection Z-axis
hz=f;
for i=1 :length(df)
uz= -cop(3)/df(i,3)
hz(i,1)=df(i,1)*uz+cop(1);
hz(i,2)=df(i,2)*uz+cop(2);
hz(i,3)=df(i,3)*uz+cop(3);
end
hz(:,3)=[]

hold on
xlabel('X-axis'),ylabel('Y-axis'),zlabel('Z-axis')
figure(1),plot3(f(:,1),f(:,2),f(:,3)),view(3)
figure(2),plot(hx(:,1),hx(:,2)),view(2)
figure(3),plot(hy(:,1),hy(:,2)),view(2)
figure(4),plot(hz(:,1),hz(:,2)),view(2)
```

```
f =

    -5     8     0
     7    -9    11
     1     4    -6

cop =

    -3     2    -7

df =

    -2     6     7
    10   -11    18
     4     2     1
```

X is remove

U1x= 3/ -2 = - 1.5
U2x= 3/ 10 = 0.3
U3x= 3/ 4 = 0.75

Y is remove

U1y= -2 / 6 = - 1 / 3
U2y= -2 / 11
U3y= -2 / 2 = - 1

H.W

Z is remove

U1x= 7 / 7 = 1
U2x= 7 / 18
U3x= 7 / 1 = 7

H.w

```
hx =

         0   -7.0000  -17.5000
         0   -1.3000   -1.6000
         0    3.5000   -6.2500


hx =

   -7.0000  -17.5000
   -1.3000   -1.6000
    3.5000   -6.2500
```

Note : Oblique Projection (H.W) { leave on student}

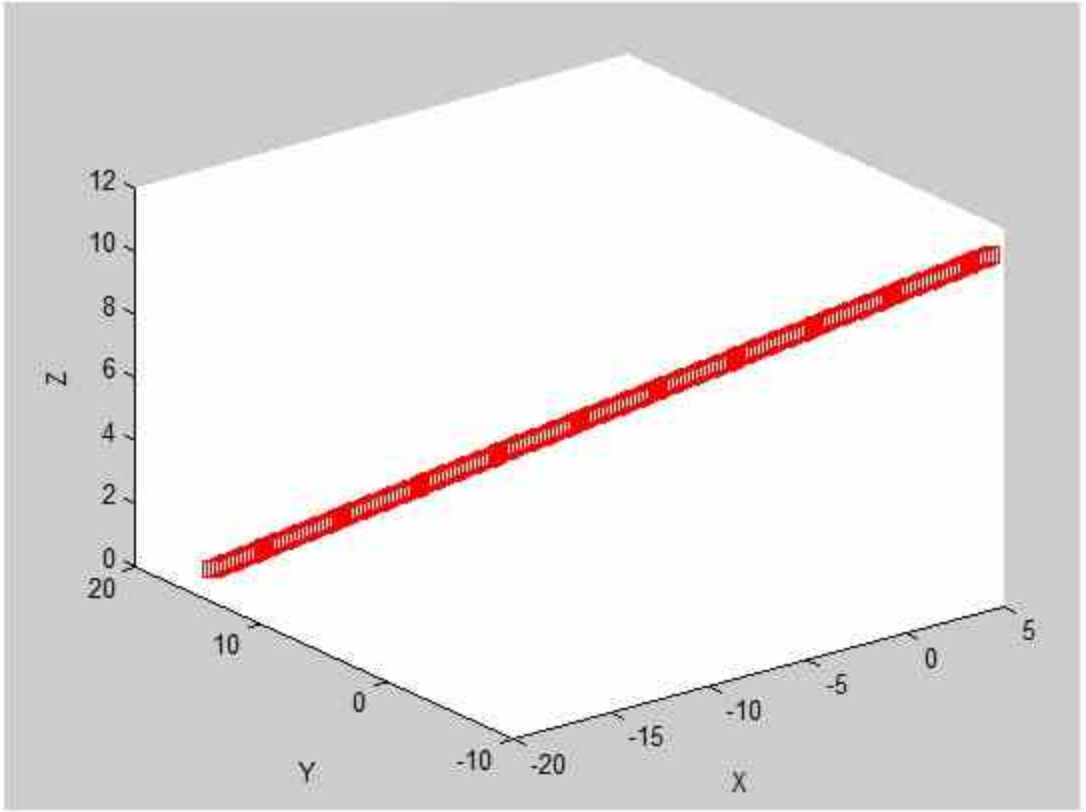
Untitled - Paint

```
1 -   clear all;clc
2 -   start=input('Start as [x1 y1 z1]= ');
3 -   finish=input('Finish as [x2 y2 z2]= ');
4 -   x1=start(1);y1=start(2);z1=start(3);
5 -   x2=finish(1);y2=finish(2);z2=finish(3);
6 -   hold on,xlabel('X');ylabel('Y');zlabel('Z');view(3)
7 -   for t=0 :0.005:1
8 -     x=(x2-x1)*t+x1;
9 -     y=(y2-y1)*t+y1;
10 -    z=(z2-z1)*t+z1;
11 -    plot3(x,y,z,'rs')
12 -  end
```

Command Window

```
Start as [x1 y1 z1]= [5 -9 11]
Finish as [x2 y2 z2]= [-20 14 1]
>>
```

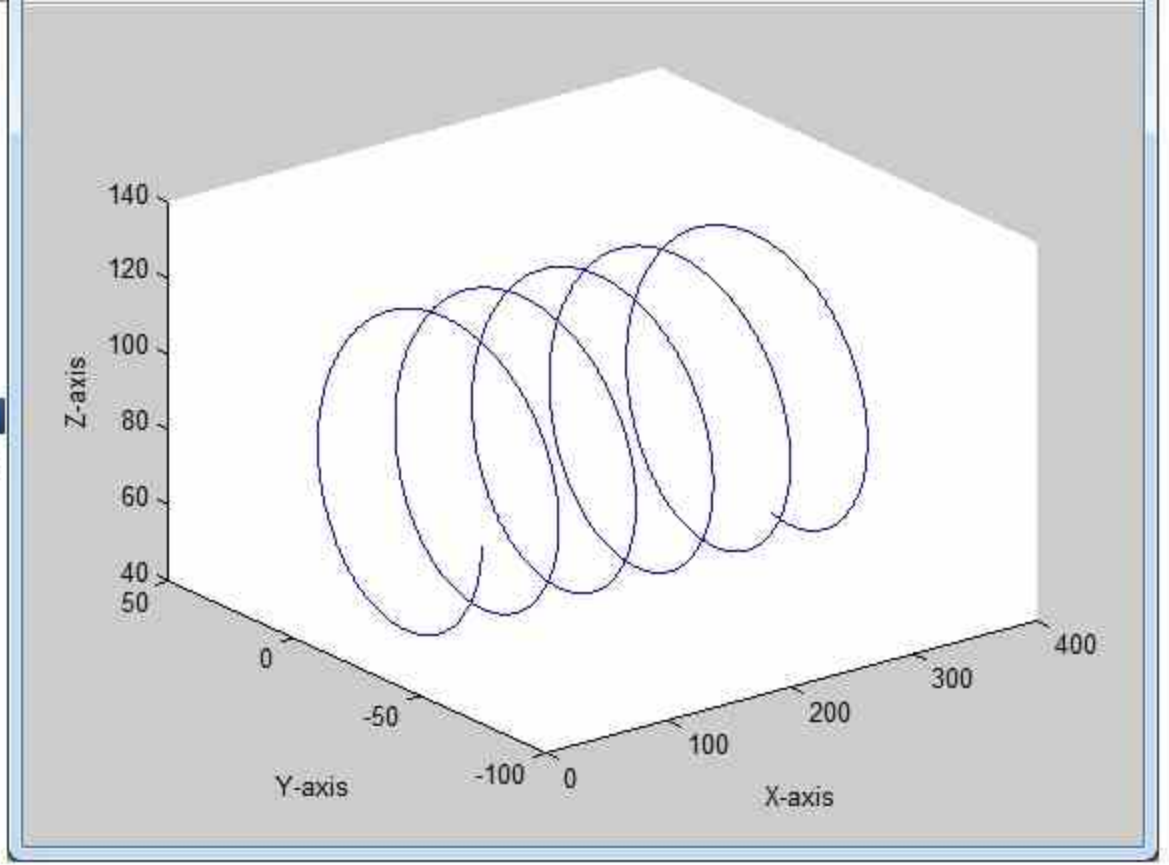
Apply===>>>



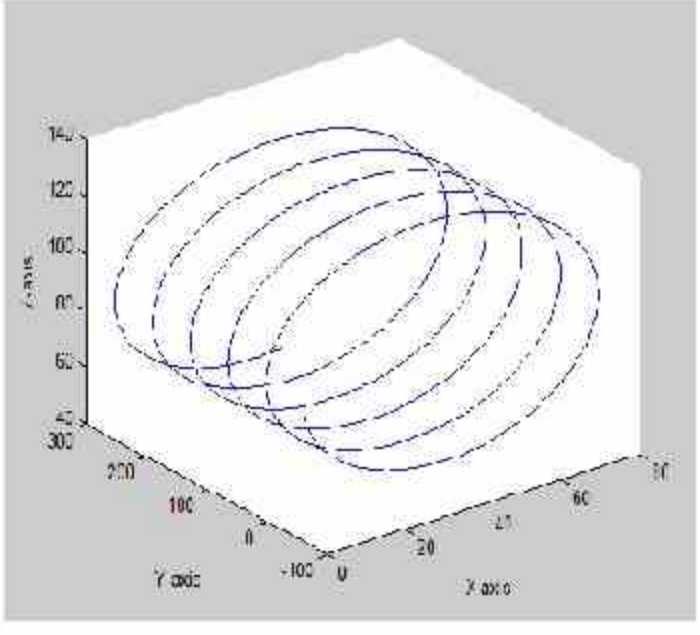
```
1 -    clear all;clc
2 -    h=input('Helix on X-axis [Xc, yc, Zc, raduis, placement]=');
3 -    r=h(4); p=h(5);
4 -    t= -3:0.01:30;
5 -    xc=h(1);yc=h(2);zc=h(3);
6 -    x=xc+p*t;
7 -    y=yc+r*cos(t);
8 -    z=zc+r*sin(t);
9 -    plot3(x,y,z);
10 -   xlabel('X-axis');ylabel('Y-axis');zlabel('Z-axis');
```

Command Window

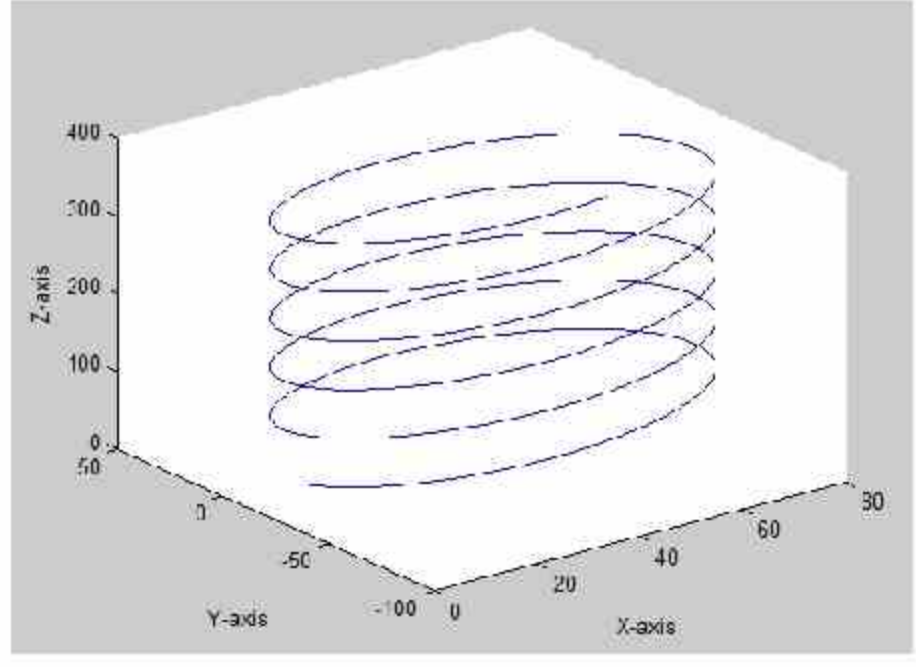
```
Helix on X-axis [Xc, yc, Zc, raduis, placement]=[40 -30 90 40 10]
>>
```



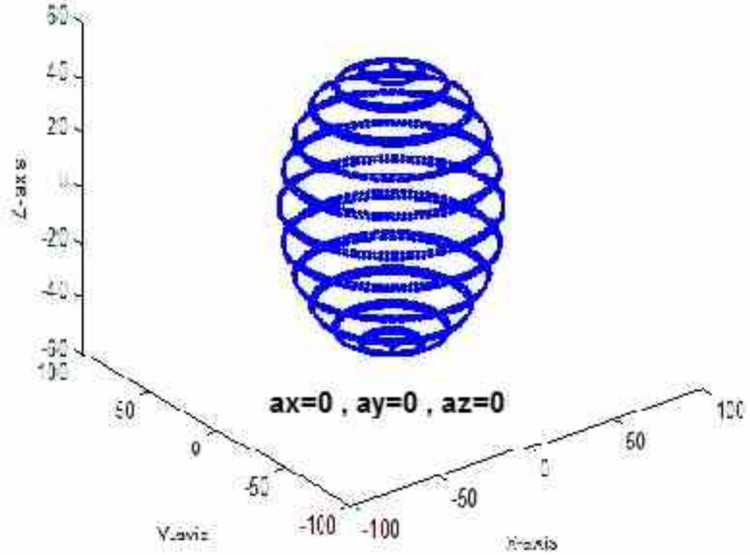
```
clear all;clc
h=input('Helix on Y-axis [Xc, yc, Zc, raduis, placement]=');
r=h(4); p=h(5);
t= -3:0.01:30;
xc=h(1);yc=h(2);zc=h(3);
x=xc+r*cos(t);
y=yc+p*t;
z=zc+r*sin(t);
plot3(x,y,z);
xlabel('X-axis');ylabel('Y-axis');zlabel('Z-axis');
```

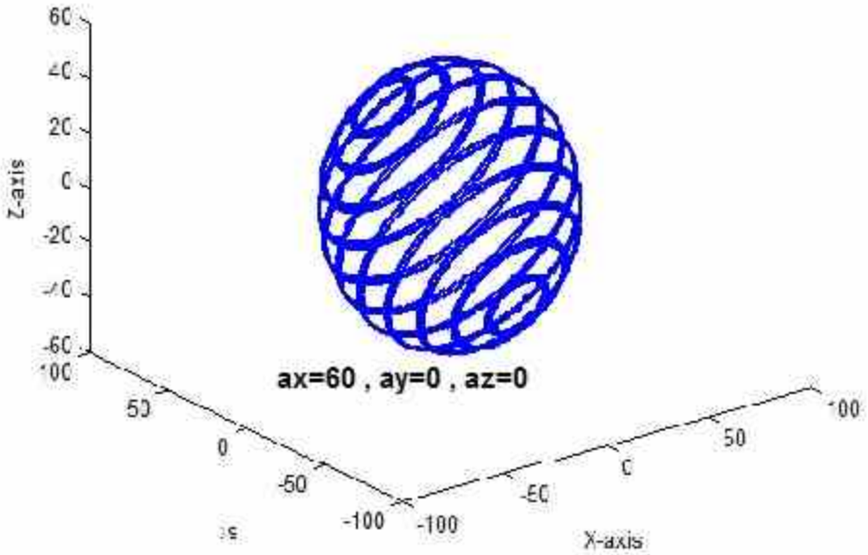


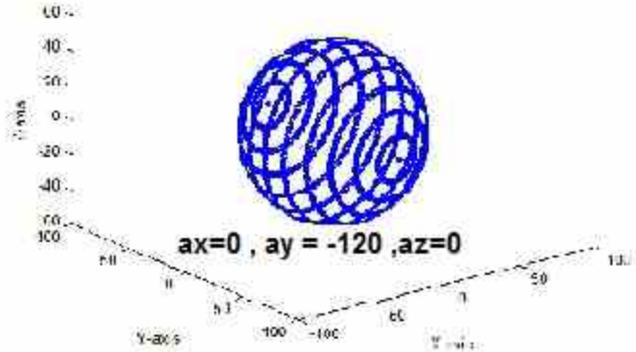

```
clear all;clc
h=input('Helix on Z-axis [Xc, yc, Zc, raduis, placement]=');
r=h(4); p=h(5);
t= -3:0.01:30;
xc=h(1);yc=h(2);zc=h(3);
x=xc+r*cos(t);
y=yc+r*sin(t);
z=zc+p*t;
plot3(x,y,z);
xlabel('X-axis');ylabel('Y-axis');zlabel('Z-axis');
```



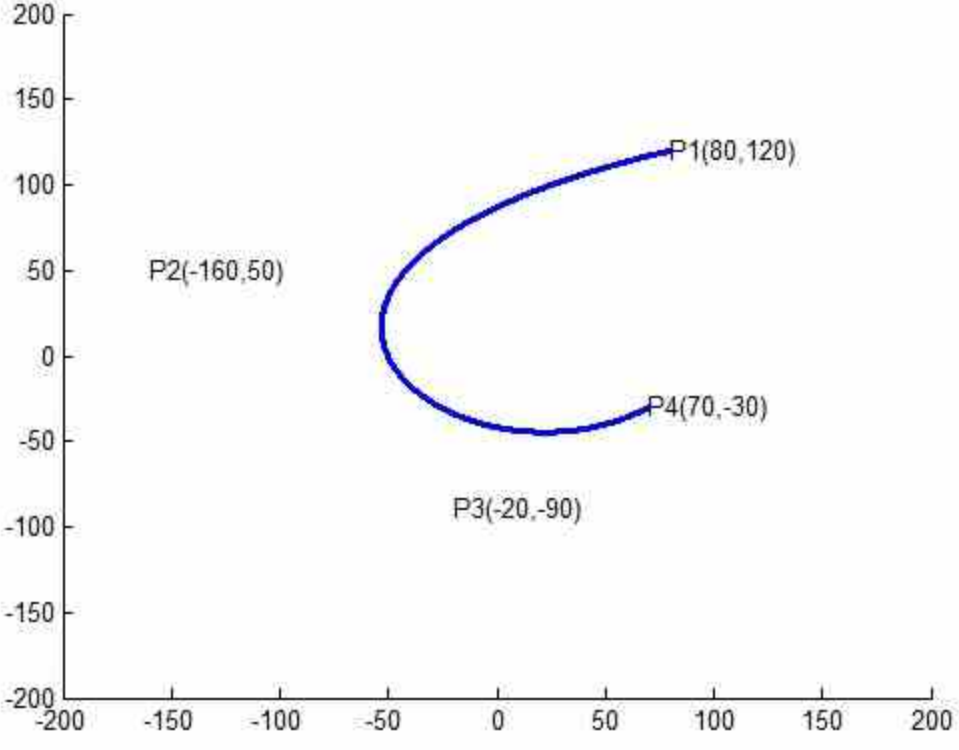
```
clear all;clc;
m=1;n=15;r=51;
ax=input('Rotate in x-axis= ');
ay=input('Rotate in y-axis= ');
az=input('Rotate in z-axis= ');
hold on

for i=1:m:360
  for j=1:n:360
  x=r*sind(j)*sind(i);
  y=r*sind(j)*cosd(i);
  z=r*cosd(j);

  x1=x*cosd(az)-y*sind(az);
  y1=y*cosd(az)+x*sind(az);

  z1=z*cosd(ax)-y1*sind(ax);
  y2=y1*cosd(ax)+z*sind(ax);

  x2=x1*cosd(ay)-z1*sind(ay);
  z2=z1*cosd(ay)+x1*sind(ay);

  plot3(x2,y2,z2);

  end
end
xlabel('X-axis');ylabel('Y-axis');zlabel('Z-axis')
view(3);
```



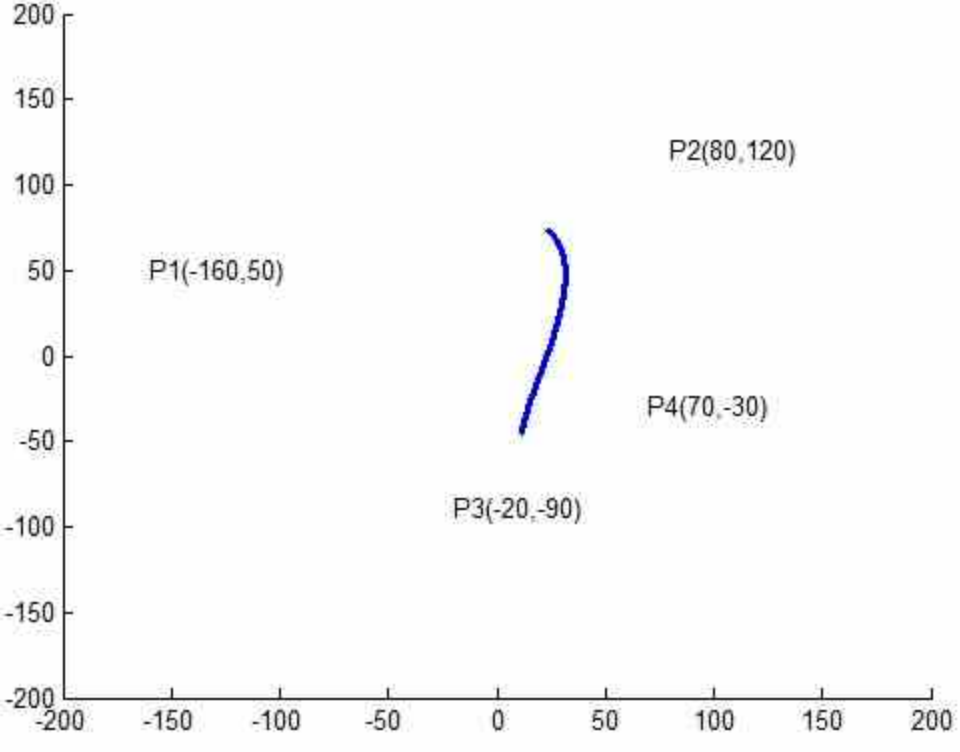




```
%X1=input('x1=');Y1=input('y1=') ;
%X2=input('x2=');Y2=input('y2=');
%X3=input('x3=');Y3=input('y3=');
%X4=input('x4=');Y4= input('y4=');
X1=80;Y1=120;X2=-160;Y2=50;
X3=-20;Y3=-90;X4=70;Y4=-30;

hold on

text(X1,Y1,sprintf('P1(%d,%d)',X1,Y1));
text(X2,Y2,sprintf('P2(%d,%d)',X2,Y2));
text(X3,Y3,sprintf('P3(%d,%d)',X3,Y3));
text(X4,Y4,sprintf('P4(%d,%d)',X4,Y4));

xlim([-200 200]);ylim([-200 200]);

for t = 0 :0.0001: 1
 x = (1 - t) ^ 3 * X1 + 3 * (1 - t) ^ 2 * t * X2 + 3 * (1 - t) * t ^ 2 * X3 + (t ^ 3) * X4;
 y = (1 - t) ^ 3 * Y1 + 3 * (1 - t) ^ 2 * t * Y2 + 3 * (1 - t) * t ^ 2 * Y3 + (t ^ 3) * Y4;
 plot(x, y)
end
```



```
%X1=input('x1=');Y1=input('y1=') ;
%X2=input('x2=');Y2=input('y2=');
%X3=input('x3=');Y3=input('y3=');
%X4=input('x4=');Y4= input('y4=');
X2=80;Y2=120;X1=-160;Y1=50;
X3=-20;Y3=-90;X4=70;Y4=-30;

hold on

text(X1,Y1,sprintf('P1(%d,%d)',X1,Y1));
text(X2,Y2,sprintf('P2(%d,%d)',X2,Y2));
text(X3,Y3,sprintf('P3(%d,%d)',X3,Y3));
text(X4,Y4,sprintf('P4(%d,%d)',X4,Y4));

xlim([-200 200]);ylim([-200 200]);

for t = 0 :0.0001: 1
 x =((1-t)^3*X1 + (3*t^3 -6*t^2 +4)*X2 + (-3*t^3 +3*t^2 +3*t+1)*X3 + t^3*X4)/6;
 y =((1-t)^3*Y1 + (3*t^3 - 6*t^2 +4)*Y2 + (-3*t^3 +3*t^2 +3*t +1)*Y3 +t^3*Y4)/6;
 plot(x, y)
end
```



Editor - E:\Ali Hassan\computer graphics\graphics_lab_matlab\Graphics_matlab\Cubic_spline_N.m

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```
3 -   for v=1:length(p)
4 -     st=  sprintf('P%d(%d,%d)',v,p(v,1),p(v,2));
5 -    text(p(v,1),p(v,2),st);
6 -    end
7 -    dx=zeros(length(p),1);dy=zeros(length(p),1);%DX1..DXn,DY1..DYn
8
9 -    ax=zeros(length(p)-1,1);bx=zeros(length(p)-1,1);%a1..a(n-1),b1..b(n-1)
10 -   cx=zeros(length(p)-1,1);ex=zeros(length(p)-1,1);%c1..c(n-1),e1..e(n-1)for X-axis
11
12 -   ay=zeros(length(p)-1,1);by=zeros(length(p)-1,1);%a1..a(n-1),b1..b(n-1)
13 -   cy=zeros(length(p)-1,1);ey=zeros(length(p)-1,1);%c1..c(n-1),e1..e(n-1)for Y-axis
14
15 -   hold on
16    %step 1:  ' find Dx and Dy all points
   dx(1) = 0; dx(length(p)) = 0;
   dy(1) = 0;    dy(length(p)) = 0;
      for i = 2 :length(p)-1
          dx(i) = ((p(i + 1,1) -p(i,1)) - (p(i,1) - p(i - 1,1))) * (3 / 2);
          dy(i) = ((p(i + 1,2) - p(i,2)) - (p(i,2) - p(i - 1,2))) * (3 / 2);
      end
 %step 2:  ' find a,b,c,e for x in all points
for j = 1 :length(p)-1
    ax(j) = (dx(j + 1) - dx(j)) / 6.0; bx(j)=dx(j)/2;
    cx(j) = (p(j + 1,1) - p(j,1)) -ax(j)-bx(j);  ex(j)=p(j,1);
             %  'find a,b,c,e for  y for all points
    ay(j) = (dy(j + 1) - dy(j)) / 6.0 ; by(j)=dy(j)/2;
    cy(j) = ((p(j + 1,2) - p(j,2))) -ay(j)-by(j) ; ey(j) = p(j,2);
    end
 %step 3 apply equ.(1)
for s = 1 :length(p)-1
  for T = 0 :0.001: 1
     xp = (T ^ 3) * ax(s) + (T ^ 2) * bx(s) + (T) * cx(s) + ex(s);
     yp = (T ^ 3) * ay(s) + (T ^ 2) * by(s) + (T) * cy(s) + ey(s);
     plot (xp, yp) % draw Curve points
  end
end
```