FISAC 3

THAKUR PRANAV GOPAL SINGH

SECTION:D ROLL NO: 48

REG: 200909426

Q1

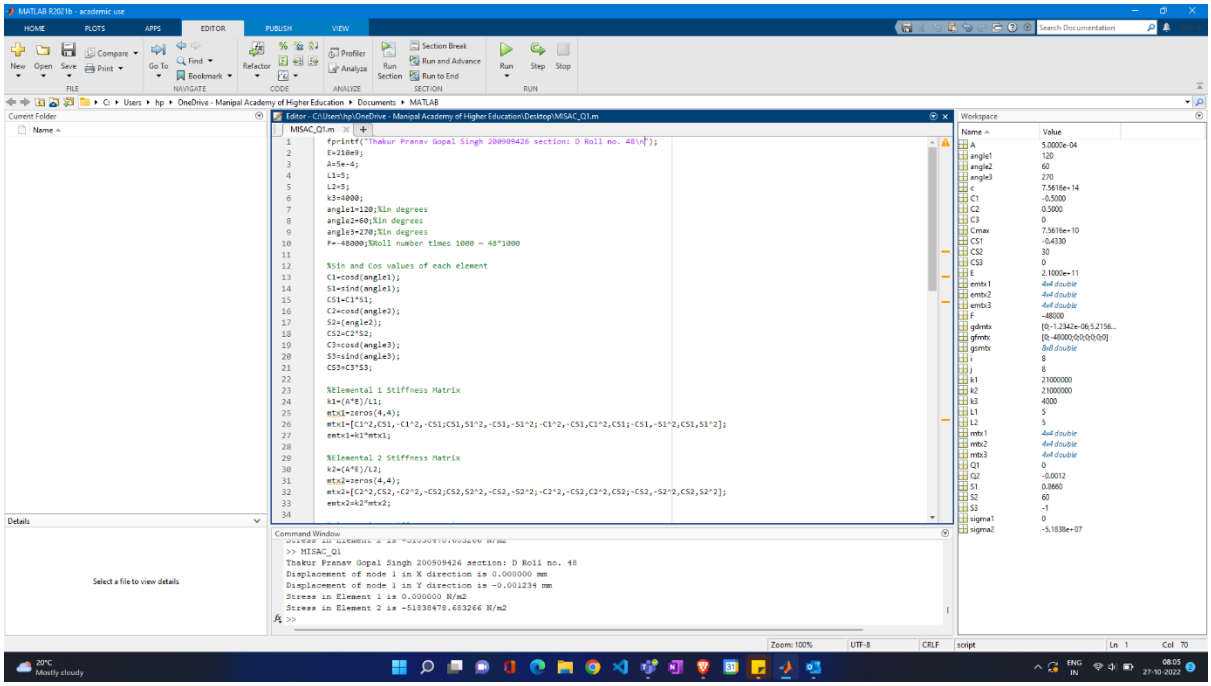
CODE:

```
fprintf("Thakur Pranav Gopal Singh 200909426 section: D Roll no. 48\n");
E=210e9;
A=5e-4;
L1=5;
L2=5;
k3=4000;
angle1=120;%in degrees
angle2=60;%in degrees
angle3=270;%in degrees
F=-48000;%Roll number times 1000 ~ 48*1000

%Sin and Cos values of each element
C1=cosd(angle1);
S1=sind(angle1);
CS1=C1*S1;
C2=cosd(angle2);
S2=(angle2);
CS2=C2*S2;
C3=cosd(angle3);
S3=sind(angle3);
CS3=C3*S3;

%Elemental 1 Stiffness Matrix
k1=(A*E)/L1;
mtx1=zeros(4,4);
mtx1=[C1^2,CS1,-C1^2,-CS1;CS1,S1^2,-CS1,-S1^2;-C1^2,-CS1,C1^2,CS1;-CS1,-
S1^2,CS1,S1^2];
emtx1=k1*mtx1;

%Elemental 2 Stiffness Matrix
k2=(A*E)/L2;
mtx2=zeros(4,4);
mtx2=[C2^2,CS2,-C2^2,-CS2;CS2,S2^2,-CS2,-S2^2;-C2^2,-CS2,C2^2,CS2;-CS2,-
S2^2,CS2,S2^2];
emtx2=k2*mtx2;

%Elemental 3 Stiffness Matrix
k3;
mtx3=zeros(4,4);
mtx3=[C3^2,CS3,-C3^2,-CS3;CS2,S3^2,-CS3,-S3^2;-C3^2,-CS3,C3^2,CS3;-CS3,-
S3^2,CS3,S3^2];
emtx3=k3*mtx3;

%Global Stiffness Matrix

gsmtx=zeros(8,8);
```

```
gsmtx(1:4,1:4)=emtx1(1:4,1:4);
gsmtx(1:2,1:2)=gsmtx(1:2,1:2)+emtx2(1:2,1:2)+emtx3(1:2,1:2);
gsmtx(1:2,5:6)=gsmtx(1:2,5:6)+emtx2(1:2,3:4);
gsmtx(5:6,1:2)=gsmtx(5:6,1:2)+emtx2(3:4,1:2);
gsmtx(5:6,5:6)=gsmtx(5:6,5:6)+emtx2(3:4,3:4);
gsmtx(1:2,7:8)=gsmtx(1:2,7:8)+emtx3(1:2,3:4);
gsmtx(7:8,1:2)=gsmtx(7:8,1:2)+emtx3(3:4,1:2);
gsmtx(7:8,7:8)=gsmtx(7:8,7:8)+emtx3(3:4,3:4);

%Global Force Matrix
gfmtx= [0;F;0;0;0;0;0;0];

%Penalty Approach
Cmax=max(gsmtx,[],'all');
c=Cmax*10^4;
for i=3:8
    gsmtx(i,i)=gsmtx(i,i)+c;
end
for j=3:8
    gfmtx(j,1)=gfmtx(j,1)+c*0;
end
gdmtx=inv(gsmtx)*gfmtx;
for i=1:8
    if -1e-6<gdmtx(i,1) && gdmtx(i,1)>1e-6
        gdmtx(i,1)=0;
    else
        continue;
    end
end

Q1=gdmtx(1,1)*10^3;
Q2=gdmtx(2,1)*10^3;
fprintf('Displacement of node 1 in X direction is %f mm\n', Q1);
fprintf('Displacement of node 1 in Y direction is %f mm\n', Q2);

%Element Stresses

%Element 1
sigma1=E*Q1/L1;
fprintf('Stress in Element 1 is %f N/m2\n', sigma1);

%Element2
sigma2=E*Q2/L2;
fprintf('Stress in Element 2 is %f N/m2\n', sigma2);
```

result:

```
>> MISAC_Q1
Thakur Pranav Gopal Singh 200909426 section: D Roll no. 48
Displacement of node 1 in X direction is 0.000000 mm
Displacement of node 1 in Y direction is -0.001234 mm
Stress in Element 1 is 0.000000 N/m2
Stress in Element 2 is -51838478.683266 N/m2
```



Q2

CODE

```
fprintf("Thakur Pranav Gopal Singh 200909426 section: D Roll no. 48\n");

%% Given values
E = 30e6;
A = 6;
cp = [-36,0,0; -144, 72, 0; -144, -72, 0; 0, 0, 144; 0,0,144];

%% direction cosines and length calculations

%% Element 1

a1 = cp(1,1)-cp(4,1);
b1 = cp(1,2)-cp(4,2);
c1 = cp(1,3)-cp(4,3);
l1 = a1/(sqrt((a1^2)+(b1^2)+(c1^2)));
m1 = b1/(sqrt((a1^2)+(b1^2)+(c1^2)));
n1 = c1/(sqrt((a1^2)+(b1^2)+(c1^2)));
L1 = sqrt((a1^2)+(b1^2)+(c1^2));

%% Element 2

a2 = cp(2,1)-cp(4,1);
b2 = cp(2,2)-cp(4,2);
c2 = cp(2,3)-cp(4,3);
l2 = a2/(sqrt((a2^2)+(b2^2)+(c2^2)));
m2 = b2/(sqrt((a2^2)+(b2^2)+(c2^2)));
n2 = c2/(sqrt((a2^2)+(b2^2)+(c2^2)));
L2 = sqrt((a2^2)+(b2^2)+(c2^2));

%% Element 3
```

```
a3 = cp(3,1)-cp(4,1);
b3 = cp(3,2)-cp(4,2);
c3 = cp(3,3)-cp(4,3);
l3 = a3/(sqrt((a3^2)+(b3^2)+(c3^2)));
m3 = b3/(sqrt((a3^2)+(b3^2)+(c3^2)));
n3 = c3/(sqrt((a3^2)+(b3^2)+(c3^2)));
L3 = sqrt((a3^2)+(b3^2)+(c3^2));

%% Element 1 Stiffness Matrix

k1= (A*E)/L1;
mat1 = zeros (6,6);
mat1(1,:)= [(l1^2), (l1*m1), (l1*n1), - (l1^2), -(l1*m1), - (l1*n1)];
mat1(2,:)= [(l1*m1), (m1^2), (m1*n1), - (l1*m1), - (m1^2), - (m1*n1)];
mat1(3,:) = [(l1*n1), (m1*n1), (n1^2), - (l1*n1), - (m1*n1), - (n1^2)];
mat1(4,:)= [-(l1^2), -(l1*m1), - (l1*n1), (l1^2), (l1*m1), (l1*n1)];
mat1(5,:)= [-(l1*m1), - (m1^2), - (m1*n1), (l1*m1), (m1^2), (m1*n1)];
mat1(6,:) = [-(l1*n1), - (m1*n1), - (n1^2), (l1*n1), (m1*n1), (n1^2)];
esm1 = k1*mat1;
Element_Stiffness_Matrix1 = esm1

%% Element 2 Stiffness Matrix

k2= (A*E)/L2;
mat2 = zeros (6,6);
mat2(1,:)= [(l2^2), (l2*m1), (l2*n1), - (l2^2), -(l2*m2), - (l2*n2)];
mat2(2,:)= [(l2*m2), (m2^2), (m2*n2), - (l2*m2), - (m2^2), - (m2*n2)];
mat2(3,:) = [(l2*n2), (m2*n2), (n2^2), - (l2*n1), - (m2*n2), - (n2^2)];
mat2(4,:)= [-(l2^2), -(l2*m2), - (l2*n2), (l2^2), (l2*m2), (l2*n2)];
mat2(5,:)= [-(l2*m2), - (m2^2), - (m2*n2), (l2*m2), (m2^2), (m2*n2)];
mat2(6,:) = [-(l2*n1), - (m2*n2), - (n2^2), (l2*n2), (m2*n2), (n2^2)];
esm2 = k2*mat2;
Element_Stiffness_Matrix2 = esm2

%% Element 3 Stiffness Matrix

k3= (A*E)/L3;
mat3 = zeros (6,6);
mat3(1,:)= [(l3^2), (l3*m3), (l3*n3), - (l3^2), -(l3*m3), - (l3*n3)];
mat3(2,:)= [(l3*m3), (m3^2), (m3*n3), - (l3*m3), - (m3^2), - (m3*n3)];
mat3(3,:) = [(l3*n3), (m3*n3), (n3^2), - (l3*n3), - (m3*n3), - (n3^2)];
mat3(4,:)= [-(l3^2), -(l3*m3), - (l3*n3), (l3^2), (l3*m3), (l3*n3)];
mat3(5,:)= [-(l3*m3), - (m3^2), - (m3*n3), (l3*m3), (m3^2), (m3*n3)];
mat3(6,:) = [-(l3*n3), - (m3*n3), - (n3^2), (l3*n3), (m3*n3), (n3^2)];
esm3 = k3*mat3;
Element_Stiffness_Matrix3 = esm3

%Global Stiffness matrix

gsm=zeros(12,12);
gsm(1:6,1:6)=gsm(1:6,1:6)+esm1(1:6,1:6);
gsm(1:3, 1:3)=gsm(1:3, 1:3)+esm2(1:3, 1:3)+esm3(1:3, 1:3);
gsm(1:3,7:9)=gsm(1:3,7:9)+esm2(1:3,4:6);
gsm(7:9,1:3)=gsm(7:9,1:3)+esm2(4:6,1:3);
gsm(7:9,7:9)=gsm(7:9,7:9)+esm2(4:6,4:6);
gsm(1:3, 10:12)=gsm(1:3, 10:12)+esm3(1:3,4:6);
gsm(10:12,1:3)=gsm(10:12,1:3)+esm3 (4:6,1:3);
gsm(10:12, 10:12) = gsm(10:12, 10:12)+esm3(4:6,4:6);
Global_Stiffness_Matrix=gsm
```

```
%Global Force Matrix

gfm=[0;0;0;0;0;0;0;0;0;0;0;-4800]; %% Force is 48*100 lbs
Global_Force_Vector=gfm

%Penalty Approach

Cmax=max(gsm,[],'all');
c=Cmax*(10^4);
for i=4:12
    gsm(i,i)=gsm(i,i)+c;
end
for j=4:12
    gfm(j,1)=gfm(j,1)+c*0;
end
gdv=inv(gsm)*gfm;

for b=1:12 %this loop compensates the error due to inverse calculation
    if abs(gdv(b,1))<1e-6
        gdv(b:1)=0;
    else
        continue;
    end
end

Global_Displacement_Matrix = gdv
qx=gdv(10,1)*(25.4); %Conversion from inch to mm
qy=gdv(11,1)*(25.4);
qz=gdv(12,1)*(25.4);
fprintf('The displacement of node 4 in X direction is %fmm\n',qx);
fprintf('The displacement of node 4 in Y direction is %fmm\n',qy);
fprintf('The displacement of node 4 in Z direction is %fmm\n',qz);

%Element Stress Calculations

%Element 1

q1=zeros(6,1);
q1=gdv(1:6,1);
sigma1=(E/L1)*[-l1,-m1,-n1,l1,m1,n1]*q1;
fprintf('The elemental stress in element 1 is %fpsi\n',sigma1);
strain1=sigma1/E;
fprintf('The strain in the element 1 is %f\n', strain1);

%Element 2

q2=zeros(6,1);
q2(1:3,1)=gdv(1:3,1);
q2(4:6,1)=gdv(7:9,1);
sigma2=(E/L2)*[-l2,-m2,-n2,l2,m2,n2]*q2;
fprintf('The elemental stress in element 2 is %fpsi\n',sigma2);
strain2=sigma2/E;
fprintf('The strain in the element 2 is %f\n', strain2);

%Element 3

q3=zeros(6,1);
q3(1:3,1)=gdv(1:3,1);
```

```
q3(4:6,1)=gdv(10:12,1);
sigma3=(E/L3)*[-l3,-m3,-n3,l3,m3,n3]*q3;
fprintf('The elemental stress in element 3 is %fpsi\n',sigma3);
strain3=sigma3/E;
fprintf('The strain in the element 3 is %f\n', strain2);
```

Result:

```
>> MISAC_Q2
Thakur Pranav Gopal Singh 200909426 section: D Roll no. 48

Element_Stiffness_Matrix1 =

   1.0e+06 *

    0.0713         0    0.2853   -0.0713         0   -0.2853
         0         0         0         0         0         0
    0.2853         0    1.1413   -0.2853         0   -1.1413
   -0.0713         0   -0.2853    0.0713         0    0.2853
         0         0         0         0         0         0
   -0.2853         0   -1.1413    0.2853         0    1.1413


Element_Stiffness_Matrix2 =

   1.0e+05 *

    3.7037         0    5.3897   -3.7037    1.8519   -3.7037
   -1.8519    0.9259   -1.8519    1.8519   -0.9259    1.8519
    3.7037   -1.8519    3.7037   -5.3897    1.8519   -3.7037
   -3.7037    1.8519   -3.7037    3.7037   -1.8519    3.7037
    1.8519   -0.9259    1.8519   -1.8519    0.9259   -1.8519
   -5.3897    1.8519   -3.7037    3.7037   -1.8519    3.7037


Element_Stiffness_Matrix3 =

   1.0e+05 *

    3.7037    1.8519    3.7037   -3.7037   -1.8519   -3.7037
    1.8519    0.9259    1.8519   -1.8519   -0.9259   -1.8519
    3.7037    1.8519    3.7037   -3.7037   -1.8519   -3.7037
   -3.7037   -1.8519   -3.7037    3.7037    1.8519    3.7037
   -1.8519   -0.9259   -1.8519    1.8519    0.9259    1.8519
   -3.7037   -1.8519   -3.7037    3.7037    1.8519    3.7037


Global_Stiffness_Matrix =

   1.0e+06 *

    0.8121    0.1852    1.1947   -0.0713         0   -0.2853   -0.3704    0.1852   -0.3704   -0.3704   -0.1852   -0.3704
         0    0.1852         0         0         0         0    0.1852   -0.0926    0.1852   -0.1852   -0.0926   -0.1852
    1.0261         0    1.8821   -0.2853         0   -1.1413   -0.5390    0.1852   -0.3704   -0.3704   -0.1852   -0.3704
   -0.0713         0   -0.2853    0.0713         0    0.2853         0         0         0         0         0         0
         0         0         0         0         0         0         0         0         0         0         0         0
   -0.2853         0   -1.1413    0.2853         0    1.1413         0         0         0         0         0         0
   -0.3704    0.1852   -0.3704         0         0         0    0.3704   -0.1852    0.3704         0         0         0
    0.1852   -0.0926    0.1852         0         0         0   -0.1852    0.0926   -0.1852         0         0         0
   -0.5390    0.1852   -0.3704         0         0         0    0.3704   -0.1852    0.3704         0         0         0
   -0.3704   -0.1852   -0.3704         0         0         0         0         0         0    0.3704    0.1852    0.3704
   -0.1852   -0.0926   -0.1852         0         0         0         0         0         0    0.1852    0.0926    0.1852
   -0.3704   -0.1852   -0.3704         0         0         0         0         0         0    0.3704    0.1852    0.3704


Global_Force_Vector =

         0
         0
         0
         0
         0
         0
         0
         0
         0
         0
         0
   -4400
```

```
Global_Displacement_Matrix =

   1.0e-06 *

         0
   -0.2338
   -0.0856
   -0.0000
         0
   -0.0000
    0.0000
   -0.0000
    0.0000
    0.0000
    0.0000
   -0.2338

The displacement of node 4 in X direction is 0.000000mm
The displacement of node 4 in Y direction is 0.000000mm
The displacement of node 4 in Z direction is -0.000006mm
The elemental stress in element 1 is -0.016781psi
The strain in the element 1 is -0.000000
The elemental stress in element 2 is 0.002898psi
The strain in the element 2 is 0.000000
The elemental stress in element 3 is 0.002898psi
The strain in the element 3 is 0.000000
>> MISAC_Q2
Thakur Pranav Gopal Singh 200909426 section: D Roll no. 48

Element_Stiffness_Matrix1 =

   1.0e+06 *

    0.0713         0    0.2853   -0.0713         0   -0.2853
         0         0         0         0         0         0
    0.2853         0    1.1413   -0.2853         0   -1.1413
   -0.0713         0   -0.2853    0.0713         0    0.2853
         0         0         0         0         0         0
   -0.2853         0   -1.1413    0.2853         0    1.1413


Element_Stiffness_Matrix2 =


   1.0e+05 *

    3.7037         0    5.3897   -3.7037    1.8519   -3.7037
   -1.8519    0.9259   -1.8519    1.8519   -0.9259    1.8519
    3.7037   -1.8519    3.7037   -5.3897    1.8519   -3.7037
   -3.7037    1.8519   -3.7037    3.7037   -1.8519    3.7037
    1.8519   -0.9259    1.8519   -1.8519    0.9259   -1.8519
   -5.3897    1.8519   -3.7037    3.7037   -1.8519    3.7037


Element_Stiffness_Matrix3 =

   1.0e+05 *

    3.7037    1.8519    3.7037   -3.7037   -1.8519   -3.7037
    1.8519    0.9259    1.8519   -1.8519   -0.9259   -1.8519
    3.7037    1.8519    3.7037   -3.7037   -1.8519   -3.7037
   -3.7037   -1.8519   -3.7037    3.7037    1.8519    3.7037
   -1.8519   -0.9259   -1.8519    1.8519    0.9259    1.8519
   -3.7037   -1.8519   -3.7037    3.7037    1.8519    3.7037


Global_Stiffness_Matrix =

   1.0e+06 *

    0.8121    0.1852    1.1947   -0.0713         0   -0.2853   -0.3704    0.1852   -0.3704   -0.3704   -0.1852   -0.3704
         0    0.1852         0         0         0         0    0.1852   -0.0926    0.1852   -0.1852   -0.0926   -0.1852
    1.0261         0    1.8821   -0.2853         0   -1.1413   -0.5390    0.1852   -0.3704   -0.3704   -0.1852   -0.3704
   -0.0713         0   -0.2853    0.0713         0    0.2853         0         0         0         0         0         0
         0         0         0         0         0         0         0         0         0         0         0         0
   -0.2853         0   -1.1413    0.2853         0    1.1413         0         0         0         0         0         0
   -0.3704    0.1852   -0.3704         0         0         0    0.3704   -0.1852    0.3704         0         0         0
    0.1852   -0.0926    0.1852         0         0         0   -0.1852    0.0926   -0.1852         0         0         0
   -0.5390    0.1852   -0.3704         0         0         0    0.3704   -0.1852    0.3704         0         0         0
   -0.3704   -0.1852   -0.3704         0         0         0         0         0         0    0.3704    0.1852    0.3704
   -0.1852   -0.0926   -0.1852         0         0         0         0         0         0    0.1852    0.0926    0.1852
   -0.3704   -0.1852   -0.3704         0         0         0         0         0         0    0.3704    0.1852    0.3704
```

```
Global_Force_Vector =

           0
           0
           0
           0
           0
           0
           0
           0
           0
           0
           0
       -4800


Global_Displacement_Matrix =

   1.0e-06 *

           0
      -0.2550
      -0.0934
      -0.0000
           0
      -0.0000
       0.0000
      -0.0000
       0.0000
       0.0000
       0.0000
      -0.2550

The displacement of node 4 in X direction is 0.000000mm
The displacement of node 4 in Y direction is 0.000000mm
The displacement of node 4 in Z direction is -0.000006mm
The elemental stress in element 1 is -0.018307psi
The strain in the element 1 is -0.000000
The elemental stress in element 2 is 0.003162psi
The strain in the element 2 is 0.000000
The elemental stress in element 3 is 0.003162psi
The strain in the element 3 is 0.000000
```