FEM_Project

December 7, 2017

```
In [857]: import numpy as np
          import sys

In [858]: p = 6625
          nu=0.3
          E=31*10**6
          G=E/(2*(1+nu))

          Ri=6
          Ro=7
          Nr=3
          Nh=10
          Deltr=(Ro-Ri)/(2*Nr)
          Delth=(np.pi/2)/(2*Nh)

          def xx(r,theta):
              return r*np.cos(theta)

          def yy(r,theta):
              return r*np.sin(theta)

          Numelem = Nr * Nh

          Numnodes= (Nh+1) * (2*Nr+1) + Nh * (Nr+1)

          NPE=8

In [859]: #Title
          CARD1 = 'PIPE: ELASTIC PLAIN STRAIN UNDER INTERNAL PRESSURE'

In [860]: #ITYPE, IGRAD, ITEM, NEIGN
          CARD2 = np.array((2,1,0,0))

In [861]: #IELTYP, NPE, MESH, NPRNT
          CARD4 = np.array((1,8,0,0))

In [862]: #NEM, NNM
          CARD5 = np.array((Numelem,Numnodes))
```

```
In [863]: # NOD
          CARD6=np.zeros((Nh*Nr,NPE))

          for i in range(0,Nh):
              for j in range(0,Nr):
                  ELENUM = i * Nr + j
                  for k in range(0,NPE):
                      if   k==0:
                          CARD6[ELENUM,k]  = i * (2 * Nr + 1) + i * (Nr + 1) + 2 * j + 1
                      elif k==1:
                          CARD6[ELENUM,k]= i * (2 * Nr + 1) + i * (Nr + 1) + 2 * j + 3
                      elif k==2:
                          CARD6[ELENUM,k]= (i + 1) * (2 * Nr + 1) + (i + 1) * (Nr + 1) + 2 * j +
                      elif k==3:
                          CARD6[ELENUM,k]= (i + 1) * (2 * Nr + 1) + (i + 1) * (Nr + 1) + 2 * j +
                      elif k==4:
                          CARD6[ELENUM,k]= i * (2 * Nr + 1) + i * (Nr + 1) + 2 * j + 2
                      elif k==5:
                          CARD6[ELENUM,k]= (i + 1) * (2 * Nr + 1) + i * (Nr + 1) +  j + 2
                      elif k==6:
                          CARD6[ELENUM,k]= (i + 1) * (2 * Nr + 1) + (i + 1) * (Nr + 1) + 2 * j +
                      elif k==7:
                          CARD6[ELENUM,k]= (i + 1) * (2 * Nr + 1) +  i * (Nr + 1) +  j + 1
```

```
In [864]: #GLXY(I,J)
          CARD7 = np.zeros((Numnodes * 2))
          n = 0
          for i in range(0, 2 * Nh + 1):
              if i % 2 == 0:
                  for j in range(0, 2 * Nr + 1):
                      r =  Ri + j * Deltr
                      theta = i * Delth
                      CARD7[n] = xx(r,theta)
                      n = n+1
                      CARD7[n] = yy(r, theta)
                      n = n+1

              if  i % 2 != 0:
                  for j in range(0, Nr + 1):
                      r =  Ri + j * Deltr * 2
                      theta = i * Delth
                      CARD7[n] = xx(r,theta)
                      n = n+1
                      CARD7[n] = yy(r, theta)
                      n = n+1
```

```
In [865]: # NSPV
          CARD15 = 4 * Nr + 2
```

In [866]:

```
# ISPV
n = 1
CARD16_1 = np.zeros((2*Nr + 1,2))

for i in range(0, 2* Nr + 1):
    CARD16_1[i,0] = n
    n = n + 1
n=1
for i in range(0, 2* Nr + 1):
    CARD16_1[i ,1] = 2

n = Numnodes - (2*Nr)
CARD16_2 = np.zeros((2*Nr + 1 ,2))
for i in range(0, 2 * Nr + 1):
    CARD16_2[i,0] = n
    n = n + 1

for i in range(0, 2*Nr + 1):
    CARD16_2[i ,1] = 1

CARD16 = np.concatenate((CARD16_1, CARD16_2)).flatten()
```

In [867]:

```
#VSPV
CARD17 =  np.zeros(( 2 * (2*(Nr + 1))))
```

In [868]:

```
#NSSV
CARD18 = 2 * (2 * Nh + 1 )
```

In [869]:

```
#ISSV
n = 0
CARD19 = np.zeros(( 2 * (2 * Nh + 1 ),2))
for i in range(0, Nh ):
        CARD19[n,0] = i * (2 * Nr + 1) + i * (Nr + 1) + 1
        CARD19[n + 1,0] = i * (2 * Nr + 1) + i * (Nr + 1) + 1
        CARD19[n + 2,0] = (i + 1) * (2 * Nr + 1) +  i * (Nr + 1) +  1
        CARD19[n + 3,0] = (i + 1) * (2 * Nr + 1) +  i * (Nr + 1) +  1
        n = n+4
CARD19[n, 0] = Nh * (2 * Nr + 1) + Nh * (Nr + 1) + 1
CARD19[n+1, 0] = Nh * (2 * Nr + 1) + Nh * (Nr + 1) + 1
n=0
for i in range(0, 2 * Nh + 1):
    CARD19[n ,1] = 1
    CARD19[n + 1 ,1] = 2
    n = n+2

CARD19 = CARD19.flatten()
```

In [870]:

```
#VSSV
CARD20 = np.zeros(((4 * Nh + 2 )))
```

```
        for i in range(0, (4 * Nh + 1 ), 2):
            if i % 4 == 0:
                CARD20[i] = 1/6 * p * 2 * Delth * Ri * np.cos(i/2*Delth)
                CARD20[i+1] = 1/6 * p * 2 * Delth * Ri * np.sin(i/2*Delth)
            else:
                CARD20[i] = 4/6 * p * 2 * Delth * Ri * np.cos(i/2*Delth)
                CARD20[i+1] = 4/6 * p * 2 * Delth * Ri * np.sin(i/2*Delth)
```

```
In [871]: #LNSTRS
          CARD29 = 0
```

```
In [872]: # E1,E2,ANU12,G12,THKNS
          CARD30 = np.array((E,E, nu, G , 1))
```

```
In [873]: # F0, FX, FY
          CARD32 = np.array((0,0,0))
```

```
In [874]: print(CARD1)
          np.savetxt(sys.stdout, CARD2[None], delimiter = ' ', fmt="%.0f")
          np.savetxt(sys.stdout, CARD4[None], delimiter = ' ', fmt="%.0f")
          np.savetxt(sys.stdout, CARD5[None], delimiter = ' ', fmt="%.0f")
          np.savetxt(sys.stdout, CARD6, delimiter = ' ', fmt="%.0f")
          np.savetxt(sys.stdout, CARD7[None], delimiter = ' ', fmt="%.8f")
          print(CARD15)
          np.savetxt(sys.stdout, CARD16[None], delimiter = ' ', fmt="%.0f")
          np.savetxt(sys.stdout, CARD17[None], delimiter = '   ', fmt="%.0f")
          print(CARD18)
          np.savetxt(sys.stdout, CARD19[None], delimiter = ' ', fmt="%.0f")
          np.savetxt(sys.stdout, CARD20[None], delimiter = ' ', fmt="%.8f")
          print(CARD29)
          np.savetxt(sys.stdout, CARD30[None], delimiter = ' ', fmt="%.1f")
          np.savetxt(sys.stdout, CARD32[None], delimiter = ' ', fmt="%.0f")
```

```
PIPE: ELASTIC PLAIN STRAIN UNDER INTERNAL PRESSURE
2 1 0 0
1 8 0 0
30 117
1 3 14 12 2 9 13 8
3 5 16 14 4 10 15 9
5 7 18 16 6 11 17 10
12 14 25 23 13 20 24 19
14 16 27 25 15 21 26 20
16 18 29 27 17 22 28 21
23 25 36 34 24 31 35 30
25 27 38 36 26 32 37 31
27 29 40 38 28 33 39 32
```

```
34 36 47 45 35 42 46 41
36 38 49 47 37 43 48 42
38 40 51 49 39 44 50 43
45 47 58 56 46 53 57 52
47 49 60 58 48 54 59 53
49 51 62 60 50 55 61 54
56 58 69 67 57 64 68 63
58 60 71 69 59 65 70 64
60 62 73 71 61 66 72 65
67 69 80 78 68 75 79 74
69 71 82 80 70 76 81 75
71 73 84 82 72 77 83 76
78 80 91 89 79 86 90 85
80 82 93 91 81 87 92 86
82 84 95 93 83 88 94 87
89 91 102 100 90 97 101 96
91 93 104 102 92 98 103 97
93 95 106 104 94 99 105 98
100 102 113 111 101 108 112 107
102 104 115 113 103 109 114 108
104 106 117 115 105 110 116 109
6.00000000 0.00000000 6.16666667 0.00000000 6.33333333 0.00000000 6.50000000 0.00000000 6.666666
14
1 2 2 2 3 2 4 2 5 2 6 2 7 2 111 1 112 1 113 1 114 1 115 1 116 1 117 1
0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
42
1 1 1 2 8 1 8 2 12 1 12 2 19 1 19 2 23 1 23 2 30 1 30 2 34 1 34 2 41 1 41 2 45 1 45 2 52 1 52 2
1040.65256650 0.00000000 4149.77832776 326.59463734 1027.84040654 162.79392753 4047.59701300 971
0
31000000.0 31000000.0 0.3 11923076.9 1.0
0 0 0
```

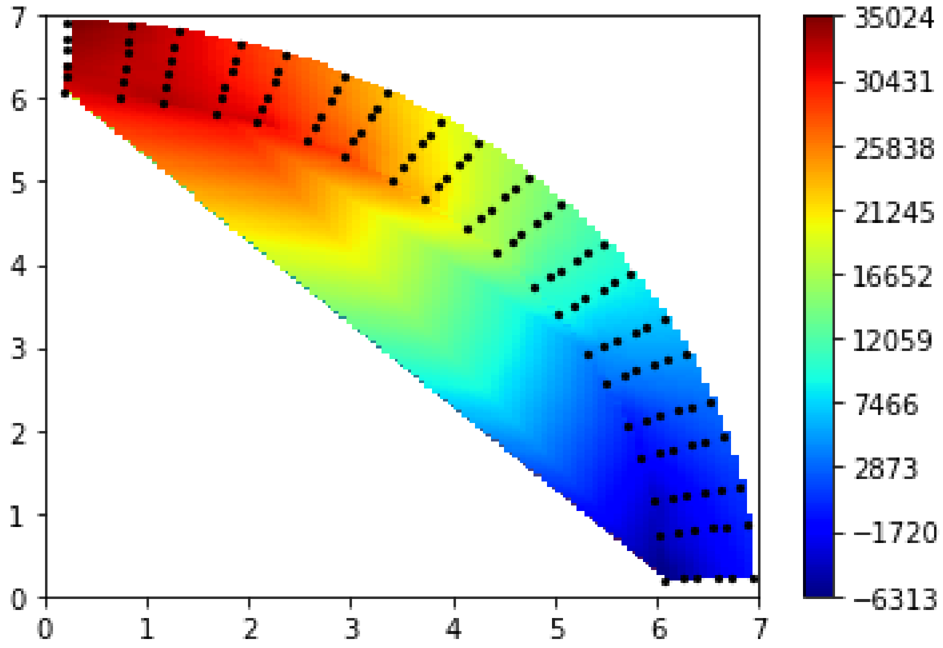
```
In [894]: results=np.loadtxt('C:/Users/Nastac/Documents/MikkoKarkkainen/School/Intro to FEM/FEM2
```

```
In [895]: x = results[::,0]
          y = results[::,1]
          sigma_x = results[::,2]
          sigma_y = results[::,3]
          sigma_z = results[::,4]
```

```
In [896]: import matplotlib.pyplot as plt
          from matplotlib.mlab import griddata
```

```
In [897]: plt.figure()
          xi = np.linspace(0, 7, 100)
          yi = np.linspace( 0,  7, 200)
          zi= griddata(x,y,sigma_x ,xi, yi, interp='linear')
          CS = plt.contourf(xi, yi, zi, 15,
                            vmax=zi.max(), vmin=zi.min())
          plt.pcolor(xi, yi, zi, cmap=plt.get_cmap('jet'))
          cbar=plt.colorbar(ticks=np.linspace(zi.min(),zi.max(),10))
          plt.scatter(x, y, marker='o', s=5, zorder=10, color='black')

          plt.show()
```



```
In [898]: print((sigma_y).min())
```

```
-6468.0
```

```
In [899]: print((sigma_x).min())
```

```
-6468.0
```

```
In [900]: print(sigma_x.max())
```

```
35270.0
```

```
In [901]: print(sigma_y.max())
```

```
35270.0
```

```
In [902]: print((-nu*(sigma_x+sigma_y)).max())
```

```
-7557.6
```