

Q2 - Assignment 9 | ME7223

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In [28]:

```
1 import numpy as np
2 import matplotlib.pyplot as plt
3 from sympy import symbols, solve
4 from scipy.optimize import minimize
5 import scipy
6 import math
7 import matplotlib.pyplot as plt
```

In [29]:

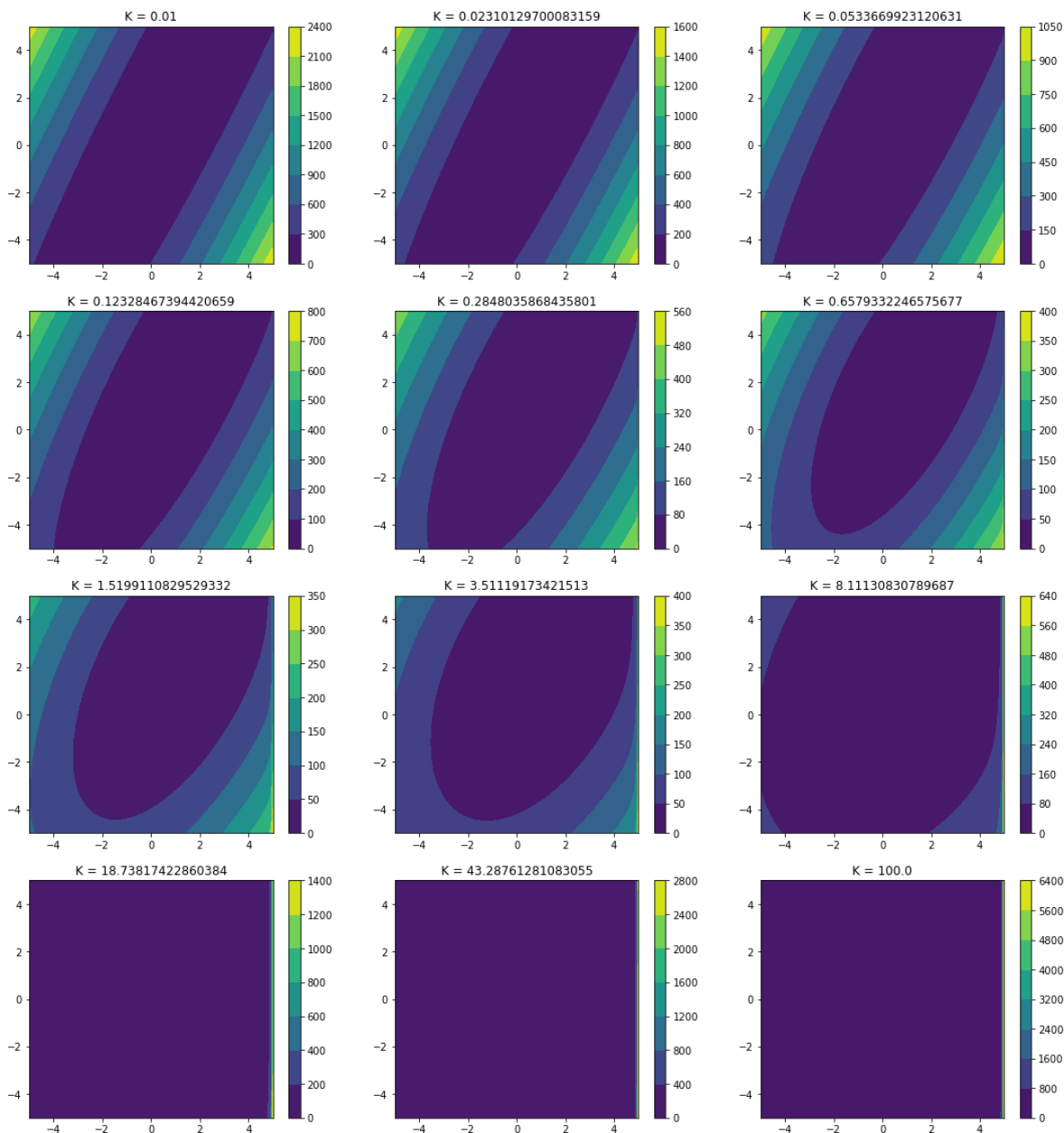
```
1 def f(x):
2     return (x[0]-1)**2+(x[1]-2)**2
3
4 def g1(x):
5     return 2*x[0]-x[1]
6
7 def g2(x):
8     return x[0]-5
9
10 def diff_f(x):
11     df0 = 2*(x[0]-1)
12     df1 = 2*(x[1]-2)
13     return np.array([df0,df1])
14
15
16 def norm(x):
17     return math.sqrt(x[0]**2 + x[1]**2)
18
19 def penalty_inner(x, k):
20     if g2(x) != 0:
21         g2_coeff = 1 / g2(x)
22         h_coeff = g1(x)**2
23         return f(x) - k * g2_coeff + (1/math.sqrt(k))*h_coeff
```

In [25]:

```

1  xmin = -5
2  xmax = 5
3  ymin = -5
4  ymax = 5
5  x = np.linspace(xmin, xmax, 600)
6  y = np.linspace(ymin, ymax, 600)
7  xx, yy = np.meshgrid(x, y)
8
9  arr = np.linspace(-10, 10, 12)
10 k_arr = 10**(0.2*arr)
11 k_arr = np.reshape(k_arr, (4,3))
12
13 fig = plt.figure(figsize=(25, 20))
14 for i in range(k_arr.shape[0]):
15     for j in range(k_arr.shape[1]):
16         zz = np.array([penalty_inner(xy, k_arr[i,j]) for xy in np.c_[xx.ravel(), yy.ravel()]])
17         fig.add_subplot(4, 4, 4*i + j + 1)
18         plt.contourf(xx, yy, zz)
19         plt.colorbar()
20         plt.title('K = ' + str(k_arr[i,j]))
21 plt.show()

```



From the above graphs we can see that $k=0.01$ gives us the best separation of all. We take initial k as 0.01 and decay as 0.8 for the following loop calculations.

In [30]:

```

1 x = [1,3]
2 print(0, '- Coordinate:', x, '- Objective Function:', f(x))
3 i = 0
4 max_iter = 20
5 eps = 2e-5
6 err = norm(diff_f(x))
7 k = 0.01
8 k_decay = 0.8
9 penalty_f = lambda x: penalty_inner(x, k)
10
11 while err > eps and i<max_iter:
12     residual = minimize(penalty_f, x)
13     x_new = residual['x']
14     x = x_new
15     err = norm(diff_f(x))
16     i =i+1
17     k = k_decay * k
18     print(i, '- Coordinate:', x, '- Objective Function:', f(x), 'K value:', k)

```

```

0 - Coordinate: [1, 3] - Objective Function: 1
1 - Coordinate: [0.99993263 1.99987757] - Objective Function: 1.952748874929
48e-08 K value: 0.008
2 - Coordinate: [0.99994638 1.99990155] - Objective Function: 1.256708057129
708e-08 K value: 0.0064
3 - Coordinate: [0.99995736 1.99992103] - Objective Function: 8.054173993510
262e-09 K value: 0.00512
4 - Coordinate: [0.99996606 1.99993665] - Objective Function: 5.165421568093
203e-09 K value: 0.004096000000000001
5 - Coordinate: [0.99997296 1.99994916] - Objective Function: 3.315828398018
1075e-09 K value: 0.0032768000000000007
6 - Coordinate: [0.99997843 1.99995918] - Objective Function: 2.131221718634
862e-09 K value: 0.002621440000000001
7 - Coordinate: [0.99998277 1.99996721] - Objective Function: 1.372216871923
736e-09 K value: 0.002097152000000001
8 - Coordinate: [0.99998428 1.99996973] - Objective Function: 1.163118648403
769e-09 K value: 0.001677721600000001
9 - Coordinate: [0.99998806 1.99997697] - Objective Function: 6.729897936556
962e-10 K value: 0.0013421772800000008
10 - Coordinate: [0.99999099 1.9999826 ] - Objective Function: 3.83747781999
14497e-10 K value: 0.0010737418240000006
11 - Coordinate: [0.99999108 1.99998259] - Objective Function: 3.82583076380
69243e-10 K value: 0.0008589934592000006
12 - Coordinate: [0.9999927 1.99998568] - Objective Function: 2.58372547539
9203e-10 K value: 0.0006871947673600005
13 - Coordinate: [0.9999941 1.9999884] - Objective Function: 1.6921687484630
227e-10 K value: 0.0005497558138880005
14 - Coordinate: [0.9999941 1.9999884] - Objective Function: 1.6921687484630
227e-10 K value: 0.0004398046511104004
15 - Coordinate: [0.99999525 1.99999059] - Objective Function: 1.11140449202
5889e-10 K value: 0.00035184372088832035
16 - Coordinate: [0.99999525 1.99999059] - Objective Function: 1.11140449202
5889e-10 K value: 0.0002814749767106563
17 - Coordinate: [0.99999629 1.99999261] - Objective Function: 6.83698039604
7215e-11 K value: 0.00022517998136852504

```