```
# EXCERCISE 4
 1
 2
 3
    import numpy as np
    import matplotlib.pyplot as plt
 4
 5
    # Create Hilbert matrix
 6
 7
    def CreateMatrix(n):
        Matrix = np.empty((n,n))
 8
        for i in range(n):
 9
            for j in range(n):
10
                 Matrix[i][j] = 1./((i+1)+(j+1)-1)
11
        return Matrix
12
13
    # Generate vector of ones
14
    def GenX(n):
15
16
        x = np.ones((n))
17
        return x
18
19
    # get solution and xhat for the matrix and x
    def SolveMatrix(n):
20
        x = GenX(n)
21
22
        M = CreateMatrix(n)
23
        b = np.dot(M,x)
        xhat = np.linalq.solve(M,b)
24
25
        return b, xhat, M, x
26
27
    # calculate the residual and the relative error and take the inf
    norms of them.
•
    # Also calculate the norm of the condition number
28
29
    def NormResidual(n):
        b,xhat,M,x = SolveMatrix(n)
30
31
        residual = b-np.dot(M,xhat)
32
        r = np.linalq.norm(residual,ord=np.inf)
        relerror = (((xhat-x)*100)/x)
33
34
        errorx = np.linalg.norm(relerror,ord =np.inf)
35
        cond = np.linalg.cond(M)
36
        return r, errorx, cond
37
38
    # define lists and amount of arrays of size nxn
    nsize = 26
39
    xlist = []
40
    Reslist = []
41
42
    Errlist = []
43
    Condloglist = []
44
    Condlist = []
45
    for i in range(2,nsize):
```

```
46
        r,errorx,cond = NormResidual(i)
47
        xlist.append(i)
48
        Reslist.append(r)
49
        Errlist.append(errorx)
        Condlist.append(cond)
50
        # take the log10 of the condition number in order to find the
51
        amount of digits that we lose
•
        Condloglist.append(np.log10(cond))
52
53
    # plot everything
54
    fig, (ax1,ax2,ax3,ax4) = plt.subplots(4,1, sharex=True)
55
    plt.suptitle("Excercise 2.6",fontsize = 30)
56
    ax1.plot(xlist,Reslist)
57
    ax1.tick params(axis='both', labelsize=17)
58
    ax1.set_ylabel('Residuals', fontsize = 15)
59
60
    ax2.plot(xlist,Errlist)
    ax2.set ylabel("Relative Error [%]", fontsize = 15)
61
    ax2.tick params(axis='both', labelsize=17)
62
    ax2.axhline(100,color='r')
63
    ax3.plot(xlist,Condlist)
64
    ax3.set ylabel("Condition Number", fontsize = 15)
65
    ax3.set xlabel("N",fontsize = 20)
66
    ax3.tick_params(axis='both', labelsize=17)
67
    ax4.set ylabel("Log10(Condition Number)", fontsize = 15)
68
    ax4.set_xlabel("N",fontsize = 20)
69
    ax4.tick params(axis='both', labelsize=17)
70
    ax4.plot(xlist,Condloglist)
71
    plt.show()
72
73
```