MA305 – Lab #6
Some Statistics & Matrices with NumPy

Due on: 11/13/2023

Work in your assigned group, prepare and submit the lab script individually!

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1. Set $N = 15$ and generate an array X of random numbers uniformly distributed in $(0, 100)$ importing `random.uniform` function from NumPy.

```
import numpy as np
X=np.random.uniform(0,100, 15)
```

and do the following:

a. Have the numbers X_i printed three on each line. Do they look "random"?

```
A=X.reshape(5,3)
print(A)
Y=A.ravel()
print(Y)
```

b. Print i, X_i in two columns nicely aligned using the fixed width format.

```
for i in range(N):
      print( '{0: 2d} \t {1:5.2f}'.format(i, X[i]) )
print(Y)
```

c. Find the minimum and maximum values (with their locations), sum, product, average, the variance (σ^2) and the standard deviation (σ) for the array X. Use `np.min, np.max, np.argmin, np.argmax, np.sum, np.prod, np.mean, np.var, np.std`

d. Print X in ascending and descending orders of magnitude in two columns nicely aligned. How many numbers are less than the average value, how many above it?

e. Compute the median value using `np.median`. How many numbers are less than the median, how many above it?

2. The heights, in cm, of a sample of 1,000 adult men and 1,000 adult women from a certain population are collected in the data files *dataM.txt* and *dataF.txt*. Read the data and calculate the mean, median and standard deviation for each sex. Create histograms for the two data sets using a suitable binning interval and plot them on the same figure.

```
import pylab
X=np.array([45,68,56,23,60,87,75,59,63,72])
np.histogram(X, bins=5, range=(0,100))
pylab.hist(X, bins=5, range=(0,100))
pylab.show()
pylab.savefig('plot.pdf')  # plot.png, plot.eps
```

3. The 1-, ∞-, and Frobenious- norms of the matrix A are defined as follows.

$$\|A\|_1 = \max_{0\le j\le N-1} \sum_{i=0}^{M-1} |a_{ij}|, \quad \|A\|_\infty = \max_{0\le i\le M-1} \sum_{i=0}^{N-1} |a_{ij}|, \quad \|A\|_F = \left(\sum_{i=0}^{M-1} \sum_{j=0}^{N-1} |a_{ij}|^2 \right)^{\frac{1}{2}}$$

For example, let $A = \begin{pmatrix} 1 & 1 \\ 0 & 1 \\ -1 & 1 \end{pmatrix}$.

$\|A\|_1 = \max\{|1| + |0| + |-1|, |1| + |1| + |1|\} = 3$ (max of column sum)

$\|A\|_\infty = \max\{|1| + |1|, |0| + |1|, |-1| + |1|\} = 2$ (max of row sum)

$\|A\|_F = \sqrt{1^2 + 0^2 + (-1)^2 + 1^2 + 1^2 + 1^2} = \sqrt{5}$ (square root of the sum of squares)

a. Generate a 4×5 matrix A defined as

$$A(i, j) = (-1)^{i+j}(2 * i + j)$$

and print A, $B = A^T$ and $C = AA^T$, and $\|C\|_1$, $\|C\|_\infty$ and $\|C\|_F$.

b. Now increase the size of the matrix A to be 1000×1000 and compute all the three norms of C, WITHOUT PRINTING THE ACTUAL MATRICES!!! Also compute the execution timing for your code.

```
import time
start = time.time()    # get the start time
.....................................
THE PORTION OF YOUR CODE TO BE TESTED
.....................................
end = time.time()
print('time to run the code:', end-start)


```

4. Solve the following system of linear equations using `numpy.linalg.solve`.

$$A = \begin{pmatrix} 7 & 1 & -1 & 2 \\ 1 & 8 & 0 & -2 \\ -1 & 0 & 4 & -1 \\ 2 & -2 & -1 & 6 \end{pmatrix}, \qquad b = \begin{pmatrix} 3 \\ -5 \\ 4 \\ -3 \end{pmatrix}$$

The exact solution is $x = (1, -1, 1, -1)^T$.

5. Import the tridiagonal system solver `trid()` from the file `tridiag.py` and solve the following linear system.

$$\begin{pmatrix} 2 & 2 & 0 & 0 \\ 2 & 4 & 4 & 0 \\ 0 & 1 & 3 & 3 \\ 0 & 0 & 2 & 5 \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{pmatrix} = \begin{pmatrix} 4 \\ 6 \\ 7 \\ 10 \end{pmatrix}.$$

6. Make a log of your work `lab6.py` and the results from **1**–**4** using the Unix command `script`, edit and clean up the typescript file and rename it as `your_name_lab6script.txt`.

7. Submit your code `lab6.py` and the file `your_name_lab6script.txt` through Canvas.
