Data-X HW1 Sp18

February 8, 2018

1 Homework 1

In this homework, you will get a chance to do some exercises with Numpy, Pandas, and Matplotlib to show us your understanding with this libraries.

If you have questions, Google! Additionally you can ask your peers questions on Piazza and/or go to Office Hours.

This homework is due **Thursday Feb. 8th, 2018 at 11:59 PM**. Please upload your .ipynb to your private repo on Github. Additionally, submit a pdf on bCourses and in the comment section include a link to your private repo.

This homework is long, please start early!

```
In [19]: import numpy as np
         import pandas as pd
         import matplotlib.pyplot as plt
         %matplotlib inline
```

1.1 NumPy Basics

Create two numpy arrays (`a` and `b`). `a` should be all integers between 10-19 (inclusive), and `b` should be ten evenly spaced numbers between 1-7. Print the results below.

```
In [20]: a = np.arange(10, 20)
         b = np.linspace(1, 7, 10)

         print("a: ", a)
         print("b: ", b)
```

```
a:  [10 11 12 13 14 15 16 17 18 19]
b:  [ 1.          1.66666667  2.33333333  3.          3.66666667  4.33333333
  5.          5.66666667  6.33333333  7.        ]
```

For `a` and `b` above do the follow and print out the results.

1. Square all the elements in both arrays (element-wise).

2. Add both the squared arrays (e.g. [1,2] + [3,4] = [4,6]).

3. Sum the elements with even indices of the added array.
4. Take the square root of the added array (element-wise square root).

```
In [21]: # Variables
         a_sq = np.square(a)
         b_sq = np.square(b)
         added_array = a_sq + b_sq
         indices = np.array([x for x in range(0, len(added_array), 2)])

         print("1. ", "a: ", a_sq, " - b: ",  b_sq)
         print("2. ", added_array)
         print("3. ", np.sum(added_array[indices]))
         # print("4. ", np.sqrt(np.sum(added_array)))
         print("4. ", np.sqrt(added_array))
```

```
1.  a:  [100 121 144 169 196 225 256 289 324 361]  - b:  [  1.           2.77777778   5.44444444
  18.77777778  25.          32.11111111  40.11111111  49.        ]
2.  [ 101.          123.77777778  149.44444444  178.          209.44444444
  243.77777778  281.          321.11111111  364.11111111  410.        ]
3.  1105.0
4.  [ 10.04987562  11.12554618  12.22474721  13.34166406  14.47219556
  15.61338457  16.76305461  17.91957341  19.08169571  20.24845673]
```

Append `b` to `a`. Reshape the appended array so that it is a 5x4, 2D-array and store the results in a variable called `m`. Print `m`.

```
In [22]: m = np.reshape(np.concatenate((a,b)), (5, 4))

         print("m: ", m)
```

```
m:  [[ 10.          11.          12.          13.        ]
 [ 14.          15.          16.          17.        ]
 [ 18.          19.           1.           1.66666667]
 [  2.33333333   3.           3.66666667   4.33333333]
 [  5.           5.66666667   6.33333333   7.        ]]
```

Extract the second and the third column of the matrix `m`. Store the resulting 5x2 matrix in a new variable called `m2`. Print `m2`.

```
In [23]: m2 = m[:, [1, 2]]

         print("m2: ", m2)
```

```
m2:  [[ 11.          12.        ]
 [ 15.          16.        ]
 [ 19.           1.        ]
```

```
 [  3.          3.66666667]
 [  5.66666667   6.33333333]]
```

Take the dot product of `m2` and `m` store the results in a matrix called `m3`. Print `m3`. Note that dot product of two matrices $A \cdot B = A^T B$

```
In [24]: m3 = np.transpose(m2).dot(m)


         print("m3: ", m3)
```

```
m3:  [[ 697.33333333  748.11111111  437.88888889  482.33333333]
 [ 402.22222222  437.88888889  454.55555556  489.88888889]]
```

Round the `m3` matrix to two decimal points. Store the result in place and print the new `m3`.

```
In [25]: m3 = m3.round(2)

         print("m3: ", m3)
```

```
m3:  [[ 697.33  748.11  437.89  482.33]
 [ 402.22  437.89  454.56  489.89]]
```

Sort the `m3` array so that the highest value is at the top left, the next highest value to the right of the highest, and the lowest value is at the bottom right. Print the sorted `m3` array.

```
In [26]: sorted_m3 = np.sort(m3.reshape(8,1)).reshape(2,4)

         print("sorted m3: ", sorted_m3)
```

```
sorted m3:  [[ 697.33  748.11  437.89  482.33]
 [ 402.22  437.89  454.56  489.89]]
```

1.2 NumPy and Masks

Create an array called `f` where there are 100 equally-spaced values from 0 to pi, inclusive. Take the sin of the array `f` (element-wise) and store that in place. Print `f`.

```
In [27]: from numpy import pi

         f = np.sin(np.linspace(0, np.pi, 100))

         print("f: ", f)
```

```
f:  [  0.00000000e+00   3.17279335e-02   6.34239197e-02   9.50560433e-02
   1.26592454e-01   1.58001396e-01   1.89251244e-01   2.20310533e-01
   2.51147987e-01   2.81732557e-01   3.12033446e-01   3.42020143e-01
   3.71662456e-01   4.00930535e-01   4.29794912e-01   4.58226522e-01
   4.86196736e-01   5.13677392e-01   5.40640817e-01   5.67059864e-01
   5.92907929e-01   6.18158986e-01   6.42787610e-01   6.66769001e-01
   6.90079011e-01   7.12694171e-01   7.34591709e-01   7.55749574e-01
   7.76146464e-01   7.95761841e-01   8.14575952e-01   8.32569855e-01
   8.49725430e-01   8.66025404e-01   8.81453363e-01   8.95993774e-01
   9.09631995e-01   9.22354294e-01   9.34147860e-01   9.45000819e-01
   9.54902241e-01   9.63842159e-01   9.71811568e-01   9.78802446e-01
   9.84807753e-01   9.89821442e-01   9.93838464e-01   9.96854776e-01
   9.98867339e-01   9.99874128e-01   9.99874128e-01   9.98867339e-01
   9.96854776e-01   9.93838464e-01   9.89821442e-01   9.84807753e-01
   9.78802446e-01   9.71811568e-01   9.63842159e-01   9.54902241e-01
   9.45000819e-01   9.34147860e-01   9.22354294e-01   9.09631995e-01
   8.95993774e-01   8.81453363e-01   8.66025404e-01   8.49725430e-01
   8.32569855e-01   8.14575952e-01   7.95761841e-01   7.76146464e-01
   7.55749574e-01   7.34591709e-01   7.12694171e-01   6.90079011e-01
   6.66769001e-01   6.42787610e-01   6.18158986e-01   5.92907929e-01
   5.67059864e-01   5.40640817e-01   5.13677392e-01   4.86196736e-01
   4.58226522e-01   4.29794912e-01   4.00930535e-01   3.71662456e-01
   3.42020143e-01   3.12033446e-01   2.81732557e-01   2.51147987e-01
   2.20310533e-01   1.89251244e-01   1.58001396e-01   1.26592454e-01
   9.50560433e-02   6.34239197e-02   3.17279335e-02   1.22464680e-16]
```

Use a 'mask' and print an array that is True when `f` >= 1/2 and False when `f` < 1/2. Print an array sequence that has only those values where `f` >= 1/2.

```
In [28]: mask = f >= 1/2
         print(mask)
         print()
         print(f[mask])
```

```
[False False False False False False False False False False False False
 False False False False False  True  True  True  True  True  True  True
  True  True  True  True  True  True  True  True  True  True  True  True
  True  True  True  True  True  True  True  True  True  True  True  True
  True  True  True  True  True  True  True  True  True  True  True  True
  True  True  True  True  True  True  True  True  True  True  True  True
  True  True  True  True  True  True  True  True  True  True  True False
 False False False False False False False False False False False False
 False False False False]

[ 0.51367739  0.54064082  0.56705986  0.59290793  0.61815899  0.64278761
  0.666769    0.69007901  0.71269417  0.73459171  0.75574957  0.77614646
  0.79576184  0.81457595  0.83256985  0.84972543  0.8660254   0.88145336
```

```
 0.89599377  0.909632    0.92235429  0.93414786  0.94500082  0.95490224
 0.96384216  0.97181157  0.97880245  0.98480775  0.98982144  0.99383846
 0.99685478  0.99886734  0.99987413  0.99987413  0.99886734  0.99685478
 0.99383846  0.98982144  0.98480775  0.97880245  0.97181157  0.96384216
 0.95490224  0.94500082  0.93414786  0.92235429  0.909632    0.89599377
 0.88145336  0.8660254   0.84972543  0.83256985  0.81457595  0.79576184
 0.77614646  0.75574957  0.73459171  0.71269417  0.69007901  0.666769
 0.64278761  0.61815899  0.59290793  0.56705986  0.54064082  0.51367739]
```

1.3 NumPy and 2 Variable Prediction

Let x be the number of miles a person drives per day and y be the dollars spent on buying car fuel per day.

We have created 2 numpy arrays each of size 100 that represent x and y.
x (number of miles) ranges from 1 to 10 with a uniform noise of (0, 1/2).
y (money spent in dollars) will be from 1 to 20 with a uniform noise (0, 1).

Run the cell below.

In [29]:
```
# seed the random number generator with a fixed value
np.random.seed(500)

x=np.linspace(1,10,100)+ np.random.uniform(low=0,high=.5,size=100)
y=np.linspace(1,20,100)+ np.random.uniform(low=0,high=1,size=100)
print ('x = ',x)
print ('y= ',y)
```

```
x =  [  1.34683976   1.12176759   1.51512398   1.55233174   1.40619168
   1.65075498   1.79399331   1.80243817   1.89844195   2.00100023
   2.3344038    2.22424872   2.24914511   2.36268477   2.49808849
   2.8212704    2.68452475   2.68229427   3.09511169   2.95703884
   3.09047742   3.2544361    3.41541904   3.40886375   3.50672677
   3.74960644   3.64861355   3.7721462    3.56368566   4.01092701
   4.15630694   4.06088549   4.02517179   4.25169402   4.15897504
   4.26835333   4.32520644   4.48563164   4.78490721   4.84614839
   4.96698768   5.18754259   5.29582013   5.32097781   5.0674106
   5.47601124   5.46852704   5.64537452   5.49642807   5.89755027
   5.68548923   5.76276141   5.94613234   6.18135713   5.96522091
   6.0275473    6.54290191   6.4991329    6.74003765   6.81809807
   6.50611821   6.91538752   7.01250925   6.89905417   7.31314433
   7.20472297   7.1043621    7.48199528   7.58957227   7.61744354
   7.6991707    7.85436822   8.03510784   7.80787781   8.22410224
   7.99366248   8.40581097   8.28913792   8.45971515   8.54227144
   8.6906456    8.61856507   8.83489887   8.66309658   8.94837987
   9.20890222   8.9614749    8.92608294   9.13231416   9.55889896
   9.61488451   9.54252979   9.42015491   9.90952569  10.00659591
  10.02504265  10.07330937   9.93489915  10.0892334   10.36509991]
y=  [  1.6635012    2.0214592    2.10816052   2.26016496   1.96287558
```

```
   2.9554635    3.02881887   3.33565296   2.75465779   3.4250107
   3.39670148   3.39377767   3.78503343   4.38293049   4.32963586
   4.03925039   4.73691868   4.30098399   4.8416329    4.78175957
   4.99765787   5.31746817   5.76844671   5.93723749   5.72811642
   6.70973615   6.68143367   6.57482731   7.17737603   7.54863252
   7.30221419   7.3202573    7.78023884   7.91133365   8.2765417
   8.69203281   8.78219865   8.45897546   8.89094715   8.81719921
   8.87106971   9.66192562   9.4020625    9.85990783   9.60359778
  10.07386266  10.6957995   10.66721916  11.18256285  10.57431836
  11.46744716  10.94398916  11.26445259  12.09754828  12.11988037
  12.121557    12.17613693  12.43750193  13.00912372  12.86407194
  13.24640866  12.76120085  13.11723062  14.07841099  14.19821707
  14.27289001  14.30624942  14.63060835  14.2770918   15.0744923
  14.45261619  15.11897313  15.2378667   15.27203124  15.32491892
  16.01095271  15.71250558  16.29488506  16.70618934  16.56555394
  16.42379457  17.18144744  17.13813976  17.69613625  17.37763019
  17.90942839  17.90343733  18.01951169  18.35727914  18.16841269
  18.61813748  18.66062754  18.81217983  19.44995194  19.7213867
  19.71966726  19.78961904  19.64385088  20.69719809  20.07974319]
```

Find the expected value of x and the expected value of y.

Solution

Resource: (https://revisionmaths.com/advanced-level-maths-revision/statistics/uniform-distribution)

```
In [30]: # print(np.mean(x))
         print("x Expected Value: ", np.average(x))
         print("y Expected Value: ", np.average(y))
```

```
x Expected Value:  5.78253254159
y Expected Value:  11.0129816833
```

Find the variance for x and y.

```
In [31]: print("x Variance: ", np.var(x))
         print("y Variance: ", np.var(y))
```

```
x Variance:  7.03332752948
y Variance:  30.1139035755
```

Find the co-variance of x and y.

```
In [32]: print("x Co-Variance: ", np.cov(x))
         print("y Co-Variance: ", np.cov(y))
```

```
x Co-Variance:  7.104371241894797
y Co-Variance:  30.418084419706705
```

Assume that the number of dollars spent on car fuel is only linearly dependent on the miles driven. Write code that uses a linear predictor to calculate a predicted value of y for each x.

i.e. $y_{predicted} = f(x) = mx + b$.

```
In [ ]:
```

Predict y for each value in x, put the error into an array called y_{error}.

```
In [33]: y_error =
```

```
  File "<ipython-input-33-a84fe419882b>", line 1
    y_error =
             ^
SyntaxError: invalid syntax
```

Write code that calculates the root mean square error (RMSE).

```
In [34]: rmse =
```

```
  File "<ipython-input-34-5059e2ec92a6>", line 1
    rmse =
          ^
SyntaxError: invalid syntax
```

1.4 Pandas

1.4.1 Reading a File

Read in a CSV file called 'data3.csv' into a dataframe called df.

Data description * Data source: http://www.fao.org/nr/water/aquastat/data/query/index.html * Data, units * GDP, current USD (CPI adjusted) * NRI, mm/yr * Population density, inhab/km^2 * Total area of the country, 1000 ha = 10km^2 * Total Population, unit 1000 inhabitants

Display the first 10 lines of the dataframe.

```
In [52]: import pandas as pd
```

```
In [53]: df = pd.read_csv('data3.csv')
         df[:10]
```

```
Out[53]:         Area  Area Id              Variable Name  Variable Id    Year  \
         0  Argentina      9.0  Total area of the country       4100.0  1962.0
         1  Argentina      9.0  Total area of the country       4100.0  1967.0
         2  Argentina      9.0  Total area of the country       4100.0  1972.0
         3  Argentina      9.0  Total area of the country       4100.0  1977.0
```

```
4   Argentina      9.0  Total area of the country       4100.0  1982.0
5   Argentina      9.0  Total area of the country       4100.0  1987.0
6   Argentina      9.0  Total area of the country       4100.0  1992.0
7   Argentina      9.0  Total area of the country       4100.0  1997.0
8   Argentina      9.0  Total area of the country       4100.0  2002.0
9   Argentina      9.0  Total area of the country       4100.0  2007.0

       Value Symbol  Md
0   278040.0       E NaN
1   278040.0       E NaN
2   278040.0       E NaN
3   278040.0       E NaN
4   278040.0       E NaN
5   278040.0       E NaN
6   278040.0       E NaN
7   278040.0       E NaN
8   278040.0       E NaN
9   278040.0       E NaN
```

Display the column names.

```
In [54]: # FOR BETTER DISPLAY
         for name in df.columns:
             print(name)
```

```
Area
Area Id
Variable Name
Variable Id
Year
Value
Symbol
Md
```

1.4.2 Data Preprocessing

Create a mask of NAN values (i.e. apply `.isnull` on the dataframe). Inspect the mask for 'True' values, they denote NANs.
Hint: You will notice that the last 8 rows and the last column ('Other') have NAN values. You can also use df.tail() to see the last row.

Remove the bottom 8 rows from the dataframe because they contain NAN values. Also remove the column 'Other'.

```
In [55]: mask = pd.isnull(df)

         df = df[:(-8)]
         df = df.drop(['Md'], axis = 1)

         df.tail()
```

```
Out[55]:                      Area  Area Id                 Variable Name  \
         385  United States of America    231.0  National Rainfall Index (NRI)
         386  United States of America    231.0  National Rainfall Index (NRI)
         387  United States of America    231.0  National Rainfall Index (NRI)
         388  United States of America    231.0  National Rainfall Index (NRI)
         389  United States of America    231.0  National Rainfall Index (NRI)

              Variable Id    Year   Value Symbol
         385       4472.0  1981.0   949.2      E
         386       4472.0  1984.0   974.6      E
         387       4472.0  1992.0  1020.0      E
         388       4472.0  1996.0  1005.0      E
         389       4472.0  2002.0   938.7      E
```

All the columns in our dataframe are not required for analysis. Drop these columns: `Area Id`, `Variable Id`, and `Symbol` and save the new dataframe as `df1`.

```
In [56]: df.drop(['Area Id', 'Variable Id', 'Symbol'], axis = 1, inplace = True)
         df1 = df
         df1
```

```
Out[56]:                      Area                  Variable Name    Year  \
         0                   Argentina       Total area of the country  1962.0
         1                   Argentina       Total area of the country  1967.0
         2                   Argentina       Total area of the country  1972.0
         3                   Argentina       Total area of the country  1977.0
         4                   Argentina       Total area of the country  1982.0
         5                   Argentina       Total area of the country  1987.0
         6                   Argentina       Total area of the country  1992.0
         7                   Argentina       Total area of the country  1997.0
         8                   Argentina       Total area of the country  2002.0
         9                   Argentina       Total area of the country  2007.0
         10                  Argentina       Total area of the country  2012.0
         11                  Argentina       Total area of the country  2014.0
         12                  Argentina                Total population  1962.0
         13                  Argentina                Total population  1967.0
         14                  Argentina                Total population  1972.0
         15                  Argentina                Total population  1977.0
         16                  Argentina                Total population  1982.0
         17                  Argentina                Total population  1987.0
         18                  Argentina                Total population  1992.0
         19                  Argentina                Total population  1997.0
         20                  Argentina                Total population  2002.0
         21                  Argentina                Total population  2007.0
         22                  Argentina                Total population  2012.0
         23                  Argentina                Total population  2015.0
         24                  Argentina              Population density  1962.0
         25                  Argentina              Population density  1967.0
```

```
26                 Argentina            Population density  1972.0
27                 Argentina            Population density  1977.0
28                 Argentina            Population density  1982.0
29                 Argentina            Population density  1987.0
..                       ...                           ...     ...
360 United States of America            Population density  1972.0
361 United States of America            Population density  1977.0
362 United States of America            Population density  1982.0
363 United States of America            Population density  1987.0
364 United States of America            Population density  1992.0
365 United States of America            Population density  1997.0
366 United States of America            Population density  2002.0
367 United States of America            Population density  2007.0
368 United States of America            Population density  2012.0
369 United States of America            Population density  2015.0
370 United States of America   Gross Domestic Product (GDP)  1962.0
371 United States of America   Gross Domestic Product (GDP)  1967.0
372 United States of America   Gross Domestic Product (GDP)  1972.0
373 United States of America   Gross Domestic Product (GDP)  1977.0
374 United States of America   Gross Domestic Product (GDP)  1982.0
375 United States of America   Gross Domestic Product (GDP)  1987.0
376 United States of America   Gross Domestic Product (GDP)  1992.0
377 United States of America   Gross Domestic Product (GDP)  1997.0
378 United States of America   Gross Domestic Product (GDP)  2002.0
379 United States of America   Gross Domestic Product (GDP)  2007.0
380 United States of America   Gross Domestic Product (GDP)  2012.0
381 United States of America   Gross Domestic Product (GDP)  2015.0
382 United States of America  National Rainfall Index (NRI)  1965.0
383 United States of America  National Rainfall Index (NRI)  1969.0
384 United States of America  National Rainfall Index (NRI)  1974.0
385 United States of America  National Rainfall Index (NRI)  1981.0
386 United States of America  National Rainfall Index (NRI)  1984.0
387 United States of America  National Rainfall Index (NRI)  1992.0
388 United States of America  National Rainfall Index (NRI)  1996.0
389 United States of America  National Rainfall Index (NRI)  2002.0

            Value
0    2.780400e+05
1    2.780400e+05
2    2.780400e+05
3    2.780400e+05
4    2.780400e+05
5    2.780400e+05
6    2.780400e+05
7    2.780400e+05
8    2.780400e+05
9    2.780400e+05
10   2.780400e+05
```

```
11     2.780400e+05
12     2.128800e+04
13     2.293200e+04
14     2.478300e+04
15     2.687900e+04
16     2.899400e+04
17     3.132600e+04
18     3.365500e+04
19     3.583400e+04
20     3.788900e+04
21     3.997000e+04
22     4.209500e+04
23     4.341700e+04
24     7.656000e+00
25     8.248000e+00
26     8.913000e+00
27     9.667000e+00
28     1.043000e+01
29     1.127000e+01
..              ...
360    2.214000e+01
361    2.317000e+01
362    2.430000e+01
363    2.549000e+01
364    2.678000e+01
365    2.834000e+01
366    2.995000e+01
367    3.132000e+01
368    3.202000e+01
369    3.273000e+01
370    6.050000e+11
371    8.620000e+11
372    1.280000e+12
373    2.090000e+12
374    3.340000e+12
375    4.870000e+12
376    6.540000e+12
377    8.610000e+12
378    1.100000e+13
379    1.450000e+13
380    1.620000e+13
381    1.790000e+13
382    9.285000e+02
383    9.522000e+02
384    1.008000e+03
385    9.492000e+02
386    9.746000e+02
387    1.020000e+03
```

```
388   1.005000e+03
389   9.387000e+02

[390 rows x 4 columns]
```

Display all the unique values in your new dataframe for these columns: `Area`, `Variable Name`, and `Year`.

Note the Countries and the Metrics (ie.recorded variables) represented in your dataset. *Hint: Use .unique( ) method.*

```
In [57]: print('The unique values in my new dataframe for Area is: \n', np.unique(df1[['Area']])
         print('The unique values in my new dataframe for Variable Name is: \n',np.unique(df1[['
         print('The unique values in my new dataframe for Year is: \n',np.unique(df1[['Year']]))
```

```
The unique values in my new dataframe for Area is:
 ['Argentina' 'Australia' 'Germany' 'Iceland' 'Ireland' 'Sweden'
 'United States of America']

The unique values in my new dataframe for Variable Name is:
 ['Gross Domestic Product (GDP)' 'National Rainfall Index (NRI)'
 'Population density' 'Total area of the country' 'Total population']

The unique values in my new dataframe for Year is:
 [ 1962.  1963.  1964.  1965.  1967.  1969.  1970.  1971.  1972.  1973.
  1974.  1975.  1977.  1978.  1979.  1981.  1982.  1983.  1984.  1985.
  1986.  1987.  1988.  1990.  1991.  1992.  1993.  1995.  1996.  1997.
  1998.  2000.  2001.  2002.  2007.  2012.  2014.  2015.]
```

Convert the `Year` column string values to pandas datetime objects, where only the year is specified.
Hint: df1['Year'] = pd.to_datetime(pd.Series(df1['Year']).astype(int),format='%Y').dt.year
Run df1.tail() to see part of the result.

```
In [58]: df1['Year'] = pd.to_datetime(pd.Series(df1['Year']).astype(int),format='%Y').dt.year
         df1.tail()
```

```
Out[58]:                          Area                  Variable Name  Year   Value
         385  United States of America  National Rainfall Index (NRI)  1981   949.2
         386  United States of America  National Rainfall Index (NRI)  1984   974.6
         387  United States of America  National Rainfall Index (NRI)  1992  1020.0
         388  United States of America  National Rainfall Index (NRI)  1996  1005.0
         389  United States of America  National Rainfall Index (NRI)  2002   938.7
```

1.4.3 Extracting Statistics

Create a dataframe 'dftemp' to store rows where the `Area` is `Iceland`.

```
In [59]: dftemp = df1.query('Area=="Iceland"')
         dftemp
```

Out[59]:

	Area	Variable Name	Year	Value
166	Iceland	Total area of the country	1962	1.030000e+04
167	Iceland	Total area of the country	1967	1.030000e+04
168	Iceland	Total area of the country	1972	1.030000e+04
169	Iceland	Total area of the country	1977	1.030000e+04
170	Iceland	Total area of the country	1982	1.030000e+04
171	Iceland	Total area of the country	1987	1.030000e+04
172	Iceland	Total area of the country	1992	1.030000e+04
173	Iceland	Total area of the country	1997	1.030000e+04
174	Iceland	Total area of the country	2002	1.030000e+04
175	Iceland	Total area of the country	2007	1.030000e+04
176	Iceland	Total area of the country	2012	1.030000e+04
177	Iceland	Total area of the country	2014	1.030000e+04
178	Iceland	Total population	1962	1.826000e+02
179	Iceland	Total population	1967	1.974000e+02
180	Iceland	Total population	1972	2.099000e+02
181	Iceland	Total population	1977	2.221000e+02
182	Iceland	Total population	1982	2.331000e+02
183	Iceland	Total population	1987	2.469000e+02
184	Iceland	Total population	1992	2.599000e+02
185	Iceland	Total population	1997	2.728000e+02
186	Iceland	Total population	2002	2.869000e+02
187	Iceland	Total population	2007	3.054000e+02
188	Iceland	Total population	2012	3.234000e+02
189	Iceland	Total population	2015	3.294000e+02
190	Iceland	Population density	1962	1.773000e+00
191	Iceland	Population density	1967	1.917000e+00
192	Iceland	Population density	1972	2.038000e+00
193	Iceland	Population density	1977	2.156000e+00
194	Iceland	Population density	1982	2.263000e+00
195	Iceland	Population density	1987	2.397000e+00
196	Iceland	Population density	1992	2.523000e+00
197	Iceland	Population density	1997	2.649000e+00
198	Iceland	Population density	2002	2.785000e+00
199	Iceland	Population density	2007	2.965000e+00
200	Iceland	Population density	2012	3.140000e+00
201	Iceland	Population density	2015	3.198000e+00
202	Iceland	Gross Domestic Product (GDP)	1962	2.849165e+08
203	Iceland	Gross Domestic Product (GDP)	1967	6.212260e+08
204	Iceland	Gross Domestic Product (GDP)	1972	8.465069e+08
205	Iceland	Gross Domestic Product (GDP)	1977	2.226539e+09
206	Iceland	Gross Domestic Product (GDP)	1982	3.232804e+09
207	Iceland	Gross Domestic Product (GDP)	1987	5.565384e+09
208	Iceland	Gross Domestic Product (GDP)	1992	7.138788e+09
209	Iceland	Gross Domestic Product (GDP)	1997	7.596126e+09
210	Iceland	Gross Domestic Product (GDP)	2002	9.161798e+09
211	Iceland	Gross Domestic Product (GDP)	2007	2.129384e+10
212	Iceland	Gross Domestic Product (GDP)	2012	1.419452e+10

```
213  Iceland   Gross Domestic Product (GDP)  2015  1.659849e+10
214  Iceland  National Rainfall Index (NRI)  1967  8.160000e+02
215  Iceland  National Rainfall Index (NRI)  1971  9.632000e+02
216  Iceland  National Rainfall Index (NRI)  1975  1.010000e+03
217  Iceland  National Rainfall Index (NRI)  1981  9.326000e+02
218  Iceland  National Rainfall Index (NRI)  1986  9.685000e+02
219  Iceland  National Rainfall Index (NRI)  1991  1.095000e+03
220  Iceland  National Rainfall Index (NRI)  1997  9.932000e+02
221  Iceland  National Rainfall Index (NRI)  1998  9.234000e+02
```

Print the years when the National Rainfall Index (NRI) was > `950` or < `900` in Iceland using the dataframe you created in the previous question.

```
In [85]: print(dftemp[(dftemp["Variable Name"] == "National Rainfall Index (NRI)") & ((dftemp["V
```

```
        Area                  Variable Name  Year   Value
214  Iceland  National Rainfall Index (NRI)  1967   816.0
215  Iceland  National Rainfall Index (NRI)  1971   963.2
216  Iceland  National Rainfall Index (NRI)  1975  1010.0
218  Iceland  National Rainfall Index (NRI)  1986   968.5
219  Iceland  National Rainfall Index (NRI)  1991  1095.0
220  Iceland  National Rainfall Index (NRI)  1997   993.2
```

Get all the rows of df1 (from the preprocessed data section of this notebook) where the `Area` is `United States of America` and store that into a new dataframe called `df_usa`. Set the indices of the this dataframe to be the `Year` column.
Hint: Use .set_index()

```
In [83]: df_usa = df1.query('Area=="United States of America"').set_index('Year')
         df_usa
```

```
Out[83]:                         Area             Variable Name         Value
         Year
         1962  United States of America  Total area of the country  9.629090e+05
         1967  United States of America  Total area of the country  9.629090e+05
         1972  United States of America  Total area of the country  9.629090e+05
         1977  United States of America  Total area of the country  9.629090e+05
         1982  United States of America  Total area of the country  9.629090e+05
         1987  United States of America  Total area of the country  9.629090e+05
         1992  United States of America  Total area of the country  9.629090e+05
         1997  United States of America  Total area of the country  9.629090e+05
         2002  United States of America  Total area of the country  9.632030e+05
         2007  United States of America  Total area of the country  9.632030e+05
         2012  United States of America  Total area of the country  9.831510e+05
         2014  United States of America  Total area of the country  9.831510e+05
         1962  United States of America           Total population  1.918610e+05
         1967  United States of America           Total population  2.037130e+05
         1972  United States of America           Total population  2.132200e+05
```

```
1977  United States of America              Total population  2.230910e+05
1982  United States of America              Total population  2.339540e+05
1987  United States of America              Total population  2.454250e+05
1992  United States of America              Total population  2.579080e+05
1997  United States of America              Total population  2.728830e+05
2002  United States of America              Total population  2.884710e+05
2007  United States of America              Total population  3.016560e+05
2012  United States of America              Total population  3.147990e+05
2015  United States of America              Total population  3.217740e+05
1962  United States of America            Population density  1.993000e+01
1967  United States of America            Population density  2.116000e+01
1972  United States of America            Population density  2.214000e+01
1977  United States of America            Population density  2.317000e+01
1982  United States of America            Population density  2.430000e+01
1987  United States of America            Population density  2.549000e+01
1992  United States of America            Population density  2.678000e+01
1997  United States of America            Population density  2.834000e+01
2002  United States of America            Population density  2.995000e+01
2007  United States of America            Population density  3.132000e+01
2012  United States of America            Population density  3.202000e+01
2015  United States of America            Population density  3.273000e+01
1962  United States of America   Gross Domestic Product (GDP)  6.050000e+11
1967  United States of America   Gross Domestic Product (GDP)  8.620000e+11
1972  United States of America   Gross Domestic Product (GDP)  1.280000e+12
1977  United States of America   Gross Domestic Product (GDP)  2.090000e+12
1982  United States of America   Gross Domestic Product (GDP)  3.340000e+12
1987  United States of America   Gross Domestic Product (GDP)  4.870000e+12
1992  United States of America   Gross Domestic Product (GDP)  6.540000e+12
1997  United States of America   Gross Domestic Product (GDP)  8.610000e+12
2002  United States of America   Gross Domestic Product (GDP)  1.100000e+13
2007  United States of America   Gross Domestic Product (GDP)  1.450000e+13
2012  United States of America   Gross Domestic Product (GDP)  1.620000e+13
2015  United States of America   Gross Domestic Product (GDP)  1.790000e+13
1965  United States of America  National Rainfall Index (NRI)  9.285000e+02
1969  United States of America  National Rainfall Index (NRI)  9.522000e+02
1974  United States of America  National Rainfall Index (NRI)  1.008000e+03
1981  United States of America  National Rainfall Index (NRI)  9.492000e+02
1984  United States of America  National Rainfall Index (NRI)  9.746000e+02
1992  United States of America  National Rainfall Index (NRI)  1.020000e+03
1996  United States of America  National Rainfall Index (NRI)  1.005000e+03
2002  United States of America  National Rainfall Index (NRI)  9.387000e+02
```

Pivot the dataframe so that the unique `Variable Name` entries become the column entries. The dataframe values should be the ones in the `Value` column. Do this by running the lines of code below.

In [61]:
```
df_usa=df_usa.pivot(columns='Variable Name',values='Value')
df_usa.head()
```

```
Out[61]: Variable Name  Gross Domestic Product (GDP)  National Rainfall Index (NRI)  \
         Year
         1962                           6.050000e+11                            NaN
         1965                                    NaN                          928.5
         1967                           8.620000e+11                            NaN
         1969                                    NaN                          952.2
         1972                           1.280000e+12                            NaN

         Variable Name  Population density  Total area of the country  Total population
         Year
         1962                        19.93                   962909.0          191861.0
         1965                          NaN                        NaN               NaN
         1967                        21.16                   962909.0          203713.0
         1969                          NaN                        NaN               NaN
         1972                        22.14                   962909.0          213220.0
```

Rename the corresponding columns to ['GDP','NRI','PD','Area','Population'].

```
In [62]: df_usa = df_usa.rename(columns={"Gross Domestic Product (GDP)": "GDP",
                                     "National Rainfall Index (NRI)": "NRI",
                                     "Population density": "PD",
                                     "Total area of the country": "Area",
                                     "Total population": "Population"})
         df_usa
```

```
Out[62]: Variable Name           GDP     NRI     PD      Area  Population
         Year
         1962           6.050000e+11     NaN  19.93  962909.0    191861.0
         1965                    NaN   928.5    NaN       NaN         NaN
         1967           8.620000e+11     NaN  21.16  962909.0    203713.0
         1969                    NaN   952.2    NaN       NaN         NaN
         1972           1.280000e+12     NaN  22.14  962909.0    213220.0
         1974                    NaN  1008.0    NaN       NaN         NaN
         1977           2.090000e+12     NaN  23.17  962909.0    223091.0
         1981                    NaN   949.2    NaN       NaN         NaN
         1982           3.340000e+12     NaN  24.30  962909.0    233954.0
         1984                    NaN   974.6    NaN       NaN         NaN
         1987           4.870000e+12     NaN  25.49  962909.0    245425.0
         1992           6.540000e+12  1020.0  26.78  962909.0    257908.0
         1996                    NaN  1005.0    NaN       NaN         NaN
         1997           8.610000e+12     NaN  28.34  962909.0    272883.0
         2002           1.100000e+13   938.7  29.95  963203.0    288471.0
         2007           1.450000e+13     NaN  31.32  963203.0    301656.0
         2012           1.620000e+13     NaN  32.02  983151.0    314799.0
         2014                    NaN     NaN    NaN  983151.0         NaN
         2015           1.790000e+13     NaN  32.73       NaN    321774.0
```

Print the output of `df_usa.isnull().sum()`. This gives us the number of NAN values in each column. Replace the NAN values by 0, using `df_usa=df_usa.fillna(0)`. Print the output of `df_usa.isnull().sum()` again.

```
In [63]: print("Number of NAN values before: ", df_usa.isnull().sum())
         df_usa=df_usa.fillna(0)
         print("Number of NAN values after: ", df_usa.isnull().sum())
```

```
Number of NAN values before:  Variable Name
GDP            7
NRI           11
PD             7
Area           7
Population     7
dtype: int64
Number of NAN values after:  Variable Name
GDP           0
NRI           0
PD            0
Area          0
Population    0
dtype: int64
```

Calculate and print all the column averages and the column standard deviations.

```
In [64]: print("--- MEAN ---")
         for col in list(df_usa.columns.values):
             print(col, " : ", df_usa[col].mean())
         print()

         print("--- STANDARD DEVIATIONS ---")
         for col in list(df_usa.columns.values):
             print(col, " : ", df_usa[col].std())
```

```
--- MEAN ---
GDP  :  4620894736842.105
NRI  :  409.2736842105263
PD  :  16.70157894736842
Area  :  610314.7368421053
Population  :  161513.42105263157

--- STANDARD DEVIATIONS ---
GDP  :  6088655543027.329
NRI  :  493.55150338260347
PD  :  13.554620476328724
Area  :  478948.1688578794
Population  :  131380.53815298682
```

Using the `df_usa` dataframe, multiply the `Area` by 10 (so instead of 1000 ha, the unit becomes 100 ha = 1km^2). Store the result in place.

```
In [65]: df_usa.loc[:,'Area'] *= 10
         df_usa.tail()
```

```
Out[65]: Variable Name           GDP    NRI    PD       Area  Population
         Year
         2002           1.100000e+13  938.7  29.95  9632030.0    288471.0
         2007           1.450000e+13    0.0  31.32  9632030.0    301656.0
         2012           1.620000e+13    0.0  32.02  9831510.0    314799.0
         2014           0.000000e+00    0.0   0.00  9831510.0         0.0
         2015           1.790000e+13    0.0  32.73        0.0    321774.0
```

Create a new column in `df_usa` called `GDP/capita` and populate it with the calculated GDP per capita. Round the results to two decimal points. Store the result in place.

```
In [69]: df_usa['GDP/capita'] = round(df_usa['GDP']/df_usa['Population']/1000, 2)
         df_usa.head()
```

```
Out[69]: Variable Name           GDP    NRI    PD       Area  Population  GDP/capita
         Year
         1962           6.050000e+11    0.0  19.93  9629090.0    191861.0     3153.32
         1965           0.000000e+00  928.5   0.00        0.0         0.0         NaN
         1967           8.620000e+11    0.0  21.16  9629090.0    203713.0     4231.44
         1969           0.000000e+00  952.2   0.00        0.0         0.0         NaN
         1972           1.280000e+12    0.0  22.14  9629090.0    213220.0     6003.19
```

Create a new column in `df_usa` called `PD2` (i.e. population density 2). Calculate the population density. **Note: the units should be inhab/km^2**. Round the reults to two decimal point. Store the result in place.

```
In [72]: df_usa['PD2'] = round(df_usa['Population']*1000/df_usa['Area'], 2)
         df_usa.head()
```

```
Out[72]: Variable Name           GDP    NRI    PD       Area  Population  GDP/capita  \
         Year
         1962           6.050000e+11    0.0  19.93  9629090.0    191861.0     3153.32
         1965           0.000000e+00  928.5   0.00        0.0         0.0         NaN
         1967           8.620000e+11    0.0  21.16  9629090.0    203713.0     4231.44
         1969           0.000000e+00  952.2   0.00        0.0         0.0         NaN
         1972           1.280000e+12    0.0  22.14  9629090.0    213220.0     6003.19

         Variable Name    PD2
         Year
         1962           19.93
         1965             NaN
         1967           21.16
         1969             NaN
         1972           22.14
```

Find the maximum value and minimum value of the 'NRI' column in the USA (using pandas methods). What years do the min and max values occur in?

```
In [75]: print("MAX: ", df_usa["NRI"].max())
         print("MIN: ", df_usa[df_usa["NRI"] > 0]["NRI"].min())
         #print(list(df_usa.columns.values))
```

```
MAX:  1020.0
MIN:  928.5
```

1.5 Matplotlib

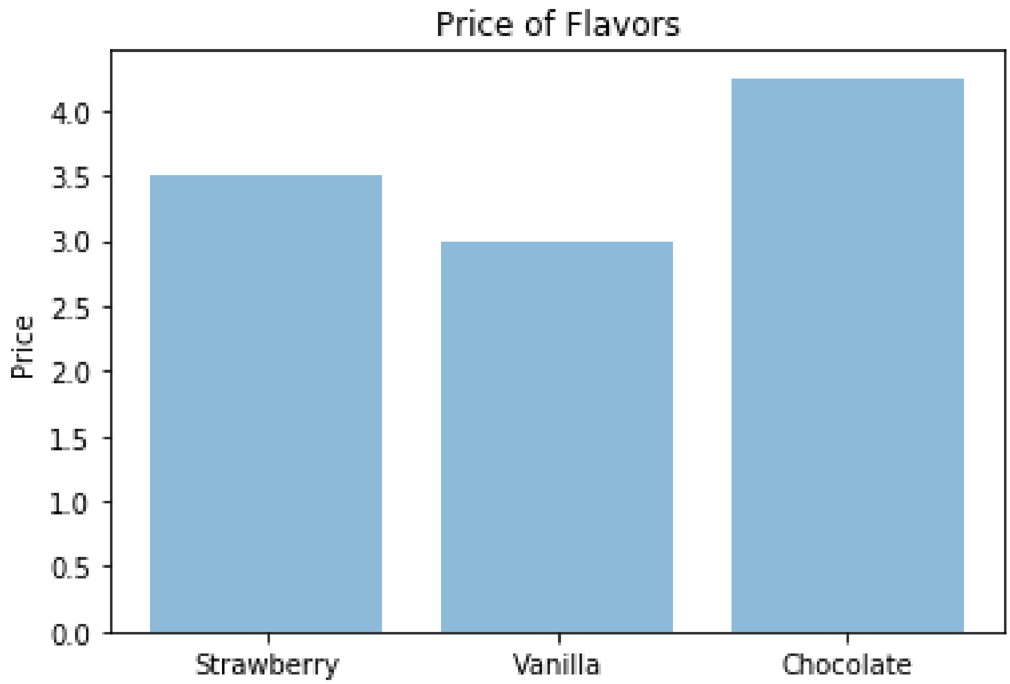
Create a dataframe called `icecream` that has column `Flavor` with entries `Strawberry`, `Vanilla`, and `Chocolate` and another column with `Price` with entries `3.50`, `3.00`, and `4.25`.

```
In [76]: df = pd.DataFrame(data={'Flavor': ['Strawberry', 'Vanilla', 'Chocolate'],
                                 'Price': [3.50, 3.00, 4.25]})
         df
```

```
Out[76]:        Flavor  Price
         0  Strawberry   3.50
         1     Vanilla   3.00
         2   Chocolate   4.25
```

Create a bar chart representing the three flavors and their associated prices.

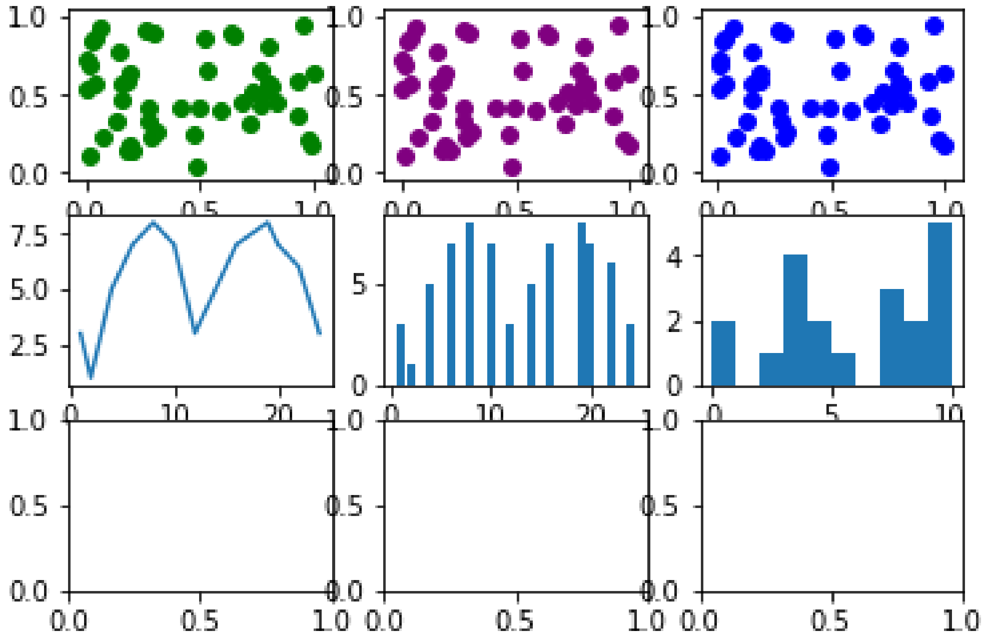
```
In [78]: objects = (df['Flavor'])
         price = list(df['Price'])

         plt.bar(np.arange(len(objects)), price, align='center', alpha=0.5)
         plt.xticks(np.arange(len(objects)), objects)
         plt.ylabel('Price')
         plt.title('Price of Flavors')

         plt.show()
```



Create 9 random plots. The top three should be scatter plots (one with green dots, one with purple crosses, and one with blue triangles. The middle three graphs should be a line graph, a horizontal bar chart, and a histogram. The bottom three graphs should be trignometric functions (one sin, one cosine, one tangent).

```
In [117]: x = np.random.rand(50,1)
          y = np.random.rand(50,1)

          x_p = [1,2,4,6,8,10,12,14,16,19,20, 22, 24]
          y_p = [3,1,5,7,8,7,3,5,7,8,7,6,3]

          f, ax = plt.subplots(nrows=3,ncols=3)

          N=20
          vals = np.random.randint(0,11,N)

          ax[0,0].scatter(x,y, c="Green")
          ax[0,1].scatter(x, y, c="Purple")
          ax[0,2].scatter(x, y, c="Blue")

          ax[1,0].plot(x_p,y_p)
          ax[1,1].bar(x_p, y_p)
          ax[1,2].hist(vals)
```

```
plt.show()
```



1.6 Extra Credit

Run the cell below to read in the data. See: https://www.quantshare.com/sa-43-10-ways-to-download-historical-stock-quotes-data-for-free

In [79]:
```
df_google = pd.read_csv('https://finance.google.com/finance/historical?output=csv&q=goo
df_apple = pd.read_csv('https://finance.google.com/finance/historical?output=csv&q=aapl

df_disney = pd.read_csv('https://finance.google.com/finance/historical?output=csv&q=dis
df_nike= pd.read_csv('https://finance.google.com/finance/historical?output=csv&q=nke')

df_apple.head()
```

Out[79]:

	Date	Open	High	Low	Close	Volume
0	8-Feb-18	160.29	161.00	155.03	155.15	53948375
1	7-Feb-18	163.08	163.40	159.07	159.54	51608580
2	6-Feb-18	154.83	163.72	154.00	163.03	68243838
3	5-Feb-18	159.10	163.88	156.00	156.49	72738522
4	2-Feb-18	166.00	166.80	160.10	160.50	86593825

Show a 3 x 3 correlation matrix for Nike, Apple, and Disney stock prices for the month of July, 2017.

Hint: Convert `Date` to a pandas datetime object. Change the indices of all the dataframes to `Date`. Use `Date` indices to filter rows. Create a new dataframe that stores values of the `Close` column from each dataframe. Use the `Close` column of each company's stock data to find the correlation using df.corr().

In [80]:
```python
df_google['Date'] = pd.to_datetime(pd.Series(df_google['Date']).astype(str),
                                   format='%d-%b-%y')
df_apple['Date'] = pd.to_datetime(pd.Series(df_apple['Date']).astype(str),
                                  format='%d-%b-%y')
df_disney['Date'] = pd.to_datetime(pd.Series(df_disney['Date']).astype(str),
                                   format='%d-%b-%y')
df_nike['Date'] = pd.to_datetime(pd.Series(df_nike['Date']).astype(str),
                                 format='%d-%b-%y')
```

In [81]:
```python
corr_google_apple = pd.concat([df_google["Close"], df_apple["Close"]], axis=1)
print("Corr Google - Apple")
print(corr_google_apple.corr(), "\n")

corr_google_disney = pd.concat([df_google["Close"], df_disney["Close"]], axis=1)
print("Corr Google - Disney")
print(corr_google_disney.corr(), "\n")

corr_google_nike = pd.concat([df_google["Close"], df_nike["Close"]], axis=1)
print("Corr Google - Nike")
print(corr_google_nike.corr(), "\n")

corr_apple_disney = pd.concat([df_apple["Close"], df_disney["Close"]], axis=1)
print("Corr Apple - Disney")
print(corr_apple_disney.corr(), "\n")

corr_apple_nike = pd.concat([df_apple["Close"], df_nike["Close"]], axis=1)
print("Corr Apple - Nike")
print(corr_apple_nike.corr(), "\n")

corr_disney_nike = pd.concat([df_disney["Close"], df_nike["Close"]], axis=1)
print("Corr Disney - Nike")
print(corr_disney_nike.corr(), "\n")
```

```
Corr Google - Apple
          Close     Close
Close  1.000000  0.871188
Close  0.871188  1.000000

Corr Google - Disney
          Close     Close
Close  1.000000 -0.195806
Close -0.195806  1.000000
```

```
Corr Google - Nike
          Close     Close
Close  1.000000  0.583454
Close  0.583454  1.000000

Corr Apple - Disney
          Close     Close
Close  1.000000 -0.297168
Close -0.297168  1.000000

Corr Apple - Nike
         Close    Close
Close  1.00000  0.48434
Close  0.48434  1.00000

Corr Disney - Nike
          Close     Close
Close  1.000000  0.389781
Close  0.389781  1.000000
```

Show the same correlation matrix but over different time periods. 1. the last 20 days
2. the last 80 days

```
In [ ]: df_google["Date" > "10-Feb-18"]
```

Change the code so that it accepts a list of any stock symbols (i.e. ['NKE', 'APPL', 'DIS', ...]) and creates a correlation matrix for the past 100 days.