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 [1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
%matplotlib inline
```

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 [2]:
```
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 [3]:
```
print("1. ", np.power(a,2), np.power(b,2) )
c = np.power(a,2)+np.power(b,2)
print("2. ", c )
d = sum(c[::2])
print("3. ", d)
e = np.sqrt(c)
print("4. ", e)
```

```
1.  [100 121 144 169 196 225 256 289 324 361] [  1.           2.77777778   5.
44444444   9.          13.44444444
  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 [4]:
```
m = np.append(a,b).reshape((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 [5]:
```
m2 = m[:,1:3]

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 [6]:
```
m3 = np.dot(m2.T,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 [7]:
```
m3 = np.around(m3, decimals=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 [8]:
```
# sorted_m3 = -np.sort(np.sort(-m3, axis=0), axis=1)
sorted_m3 = np.array([[-np.sort(-m3, axis=None)[:4]],[-np.sort(-m3, axis=None)
[4:]]])

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

```
sorted m3:  [[[ 748.11  697.33  489.89  482.33]]

 [[ 454.56  437.89  437.89  402.22]]]
```

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 [9]:
```
f = np.linspace(0,np.pi,100)
f = np.sin(f)

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 [10]:
```
print(f>=1/2)
print(f[f>=1/2])
```

```
[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]
```

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 [11]:
```
# 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.

In [12]:
```
x.mean(), y.mean()
```

Out[12]: (5.7825325415879227, 11.012981683344968)

Find the variance for x and y.

In [13]:
```
np.var(x), y.var()
```

Out[13]: (7.0333275294758497, 30.113903575509635)

Find the co-variance of x and y.

In [14]:
```
np.cov(x,y)[0,1]
```

Out[14]: 14.657743832803437

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 [15]:
```
# y_predicted = np.cov(x,y)[0,1]/x.var()*x + y - x*(np.cov(x,y)[0,1]/x.var());
 y_predicted
A = np.vstack([x, np.ones(len(x))]).T
m, b = np.linalg.lstsq(A, y)[0]
y_predicted =m*x + b; y_predicted
```

Out[15]:
```
array([  1.86125717,   1.39688809,   2.20846128,   2.28522836,
         1.98371207,   2.48829527,   2.78382468,   2.80124813,
         2.9993232 ,   3.21092152,   3.8988    ,   3.67152796,
         3.7228942 ,   3.9571493 ,   4.23651436,   4.9033035 ,
         4.62116978,   4.61656787,   5.46829307,   5.18342105,
         5.45873164,   5.79701128,   6.12915141,   6.11562653,
         6.31753758,   6.81864709,   6.61027849,   6.86515115,
         6.43505522,   7.35780389,   7.65775187,   7.46087825,
         7.38719373,   7.85455455,   7.66325667,   7.88892606,
         8.00622544,   8.33721481,   8.95468038,   9.08103323,
         9.33034895,   9.78539799,  10.00879629,  10.06070164,
         9.53754157,  10.38056671,  10.36512531,  10.72999716,
        10.42269073,  11.25028634,  10.81276185,  10.97218988,
        11.35052091,  11.83583685,  11.38990445,  11.51849632,
        12.58177632,  12.49147206,  12.98850691,  13.14956122,
        12.50588416,  13.35028889,  13.5506705 ,  13.31658991,
        14.17094102,  13.947246  ,  13.74018137,  14.51931443,
        14.74126735,  14.79877137,  14.96739089,  15.28759454,
        15.66049665,  15.1916755 ,  16.05043004,  15.57498655,
        16.42533161,  16.18461169,  16.53654675,  16.70687695,
        17.01300263,  16.86428603,  17.31062607,  16.95616347,
        17.54476017,  18.08227006,  17.57177784,  17.49875711,
        17.92425351,  18.80438359,  18.91989301,  18.77061069,
        18.51812677,  19.5277969 ,  19.72807224,  19.76613158,
        19.8657155 ,  19.58014745,  19.89856998,  20.46773797])
```

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

In [16]:
```
y_error = y_predicted - y; y_error
```

Out[16]:
```
array([ 0.19775597, -0.62457111,  0.10030076,  0.02506341,  0.02083649,
       -0.46716823, -0.24499418, -0.53440482,  0.24466541, -0.21408918,
        0.50209852,  0.27775029, -0.06213923, -0.42578118, -0.0931215 ,
        0.86405311, -0.1157489 ,  0.31558388,  0.62666017,  0.40166149,
        0.46107377,  0.47954311,  0.3607047 ,  0.17838904,  0.58942116,
        0.10891094, -0.07115518,  0.29032384, -0.74232081, -0.19082863,
        0.35553767,  0.14062095, -0.39304511, -0.0567791 , -0.61328502,
       -0.80310676, -0.77597321, -0.12176065,  0.06373323,  0.26383402,
        0.45927925,  0.12347238,  0.60673379,  0.20079382, -0.0660562 ,
        0.30670405, -0.33067419,  0.062778  , -0.75987212,  0.67596798,
       -0.65468531,  0.02820071,  0.08606832, -0.26171143, -0.72997592,
       -0.60306068,  0.40563939,  0.05397013, -0.02061681,  0.28548928,
       -0.7405245 ,  0.58908804,  0.43343988, -0.76182107, -0.02727604,
       -0.32564401, -0.56606805, -0.11129392,  0.46417555, -0.27572093,
        0.5147747 ,  0.16862142,  0.42262995, -0.08035574,  0.72551112,
       -0.43596616,  0.71282602, -0.11027337, -0.16964259,  0.14132301,
        0.58920807, -0.31716141,  0.17248631, -0.73997278,  0.16712997,
        0.17284167, -0.33165948, -0.52075457, -0.43302563,  0.6359709 ,
        0.30175553,  0.10998314, -0.29405306,  0.07784496,  0.00668554,
        0.04646431,  0.07609646, -0.06370343, -0.79862812,  0.38799477])
```

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

In [17]:
```
rmse = np.sqrt(((y_predicted - y) ** 2).mean()); rmse
```

Out[17]:
```
0.41767772366856121
```

Pandas

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 (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 [18]:
```
df = pd.read_csv("data3.csv");
df.head(10)
```

Out[18]:

	Area	Area Id	Variable Name	Variable Id	Year	Value	Symbol	Md
0	Argentina	9.0	Total area of the country	4100.0	1962.0	278040.0	E	NaN
1	Argentina	9.0	Total area of the country	4100.0	1967.0	278040.0	E	NaN
2	Argentina	9.0	Total area of the country	4100.0	1972.0	278040.0	E	NaN
3	Argentina	9.0	Total area of the country	4100.0	1977.0	278040.0	E	NaN
4	Argentina	9.0	Total area of the country	4100.0	1982.0	278040.0	E	NaN
5	Argentina	9.0	Total area of the country	4100.0	1987.0	278040.0	E	NaN
6	Argentina	9.0	Total area of the country	4100.0	1992.0	278040.0	E	NaN
7	Argentina	9.0	Total area of the country	4100.0	1997.0	278040.0	E	NaN
8	Argentina	9.0	Total area of the country	4100.0	2002.0	278040.0	E	NaN
9	Argentina	9.0	Total area of the country	4100.0	2007.0	278040.0	E	NaN

Display the column names.

In [19]:
```
df.columns.values
```

Out[19]:
```
array(['Area', 'Area Id', 'Variable Name', 'Variable Id', 'Year', 'Value',
       'Symbol', 'Md'], dtype=object)
```

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 [20]:
```
df.isnull()
df.drop(df.tail(8).index, inplace=True)
del df['Md']; df
```

Out[20]:

	Area	Area Id	Variable Name	Variable Id	Year	Value	Symbol
0	Argentina	9.0	Total area of the country	4100.0	1962.0	2.780400e+05	E
1	Argentina	9.0	Total area of the country	4100.0	1967.0	2.780400e+05	E
2	Argentina	9.0	Total area of the country	4100.0	1972.0	2.780400e+05	E
3	Argentina	9.0	Total area of the country	4100.0	1977.0	2.780400e+05	E
4	Argentina	9.0	Total area of the country	4100.0	1982.0	2.780400e+05	E
5	Argentina	9.0	Total area of the country	4100.0	1987.0	2.780400e+05	E
6	Argentina	9.0	Total area of the country	4100.0	1992.0	2.780400e+05	E
7	Argentina	9.0	Total area of the country	4100.0	1997.0	2.780400e+05	E
8	Argentina	9.0	Total area of the country	4100.0	2002.0	2.780400e+05	E
9	Argentina	9.0	Total area of the country	4100.0	2007.0	2.780400e+05	E
10	Argentina	9.0	Total area of the country	4100.0	2012.0	2.780400e+05	E
11	Argentina	9.0	Total area of the country	4100.0	2014.0	2.780400e+05	E
12	Argentina	9.0	Total population	4104.0	1962.0	2.128800e+04	E
13	Argentina	9.0	Total population	4104.0	1967.0	2.293200e+04	E
14	Argentina	9.0	Total population	4104.0	1972.0	2.478300e+04	E
15	Argentina	9.0	Total population	4104.0	1977.0	2.687900e+04	E
16	Argentina	9.0	Total population	4104.0	1982.0	2.899400e+04	E
17	Argentina	9.0	Total population	4104.0	1987.0	3.132600e+04	E
18	Argentina	9.0	Total population	4104.0	1992.0	3.365500e+04	E
19	Argentina	9.0	Total population	4104.0	1997.0	3.583400e+04	E
20	Argentina	9.0	Total population	4104.0	2002.0	3.788900e+04	E
21	Argentina	9.0	Total population	4104.0	2007.0	3.997000e+04	E
22	Argentina	9.0	Total population	4104.0	2012.0	4.209500e+04	E

	Area	Area Id	Variable Name	Variable Id	Year	Value	Symbol
23	Argentina	9.0	Total population	4104.0	2015.0	4.341700e+04	E
24	Argentina	9.0	Population density	4107.0	1962.0	7.656000e+00	E
25	Argentina	9.0	Population density	4107.0	1967.0	8.248000e+00	E
26	Argentina	9.0	Population density	4107.0	1972.0	8.913000e+00	E
27	Argentina	9.0	Population density	4107.0	1977.0	9.667000e+00	E
28	Argentina	9.0	Population density	4107.0	1982.0	1.043000e+01	E
29	Argentina	9.0	Population density	4107.0	1987.0	1.127000e+01	E
...	...	...	...	...	...	...	...
360	United States of America	231.0	Population density	4107.0	1972.0	2.214000e+01	E
361	United States of America	231.0	Population density	4107.0	1977.0	2.317000e+01	E
362	United States of America	231.0	Population density	4107.0	1982.0	2.430000e+01	E
363	United States of America	231.0	Population density	4107.0	1987.0	2.549000e+01	E
364	United States of America	231.0	Population density	4107.0	1992.0	2.678000e+01	E
365	United States of America	231.0	Population density	4107.0	1997.0	2.834000e+01	E
366	United States of America	231.0	Population density	4107.0	2002.0	2.995000e+01	E
367	United States of America	231.0	Population density	4107.0	2007.0	3.132000e+01	E
368	United States of America	231.0	Population density	4107.0	2012.0	3.202000e+01	E
369	United States of America	231.0	Population density	4107.0	2015.0	3.273000e+01	E
370	United States of America	231.0	Gross Domestic Product (GDP)	4112.0	1962.0	6.050000e+11	E
371	United States of America	231.0	Gross Domestic Product (GDP)	4112.0	1967.0	8.620000e+11	E
372	United States of America	231.0	Gross Domestic Product (GDP)	4112.0	1972.0	1.280000e+12	E
373	United States of America	231.0	Gross Domestic Product (GDP)	4112.0	1977.0	2.090000e+12	E

	Area	Area Id	Variable Name	Variable Id	Year	Value	Symbol
374	United States of America	231.0	Gross Domestic Product (GDP)	4112.0	1982.0	3.340000e+12	E
375	United States of America	231.0	Gross Domestic Product (GDP)	4112.0	1987.0	4.870000e+12	E
376	United States of America	231.0	Gross Domestic Product (GDP)	4112.0	1992.0	6.540000e+12	E
377	United States of America	231.0	Gross Domestic Product (GDP)	4112.0	1997.0	8.610000e+12	E
378	United States of America	231.0	Gross Domestic Product (GDP)	4112.0	2002.0	1.100000e+13	E
379	United States of America	231.0	Gross Domestic Product (GDP)	4112.0	2007.0	1.450000e+13	E
380	United States of America	231.0	Gross Domestic Product (GDP)	4112.0	2012.0	1.620000e+13	E
381	United States of America	231.0	Gross Domestic Product (GDP)	4112.0	2015.0	1.790000e+13	E
382	United States of America	231.0	National Rainfall Index (NRI)	4472.0	1965.0	9.285000e+02	E
383	United States of America	231.0	National Rainfall Index (NRI)	4472.0	1969.0	9.522000e+02	E
384	United States of America	231.0	National Rainfall Index (NRI)	4472.0	1974.0	1.008000e+03	E
385	United States of America	231.0	National Rainfall Index (NRI)	4472.0	1981.0	9.492000e+02	E
386	United States of America	231.0	National Rainfall Index (NRI)	4472.0	1984.0	9.746000e+02	E
387	United States of America	231.0	National Rainfall Index (NRI)	4472.0	1992.0	1.020000e+03	E
388	United States of America	231.0	National Rainfall Index (NRI)	4472.0	1996.0	1.005000e+03	E
389	United States of America	231.0	National Rainfall Index (NRI)	4472.0	2002.0	9.387000e+02	E

390 rows × 7 columns

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 [21]:
```
df1 = df.drop(['Area Id', 'Variable Id', 'Symbol'], axis=1); df1
```

Out[21]:

	Area	Variable Name	Year	Value
0	Argentina	Total area of the country	1962.0	2.780400e+05
1	Argentina	Total area of the country	1967.0	2.780400e+05
2	Argentina	Total area of the country	1972.0	2.780400e+05
3	Argentina	Total area of the country	1977.0	2.780400e+05
4	Argentina	Total area of the country	1982.0	2.780400e+05
5	Argentina	Total area of the country	1987.0	2.780400e+05
6	Argentina	Total area of the country	1992.0	2.780400e+05
7	Argentina	Total area of the country	1997.0	2.780400e+05
8	Argentina	Total area of the country	2002.0	2.780400e+05
9	Argentina	Total area of the country	2007.0	2.780400e+05
10	Argentina	Total area of the country	2012.0	2.780400e+05
11	Argentina	Total area of the country	2014.0	2.780400e+05
12	Argentina	Total population	1962.0	2.128800e+04
13	Argentina	Total population	1967.0	2.293200e+04
14	Argentina	Total population	1972.0	2.478300e+04
15	Argentina	Total population	1977.0	2.687900e+04
16	Argentina	Total population	1982.0	2.899400e+04
17	Argentina	Total population	1987.0	3.132600e+04
18	Argentina	Total population	1992.0	3.365500e+04
19	Argentina	Total population	1997.0	3.583400e+04
20	Argentina	Total population	2002.0	3.788900e+04
21	Argentina	Total population	2007.0	3.997000e+04
22	Argentina	Total population	2012.0	4.209500e+04
23	Argentina	Total population	2015.0	4.341700e+04
24	Argentina	Population density	1962.0	7.656000e+00
25	Argentina	Population density	1967.0	8.248000e+00
26	Argentina	Population density	1972.0	8.913000e+00
27	Argentina	Population density	1977.0	9.667000e+00
28	Argentina	Population density	1982.0	1.043000e+01
29	Argentina	Population density	1987.0	1.127000e+01
...	...	...	...	...
360	United States of America	Population density	1972.0	2.214000e+01

	Area	Variable Name	Year	Value
361	United States of America	Population density	1977.0	2.317000e+01
362	United States of America	Population density	1982.0	2.430000e+01
363	United States of America	Population density	1987.0	2.549000e+01
364	United States of America	Population density	1992.0	2.678000e+01
365	United States of America	Population density	1997.0	2.834000e+01
366	United States of America	Population density	2002.0	2.995000e+01
367	United States of America	Population density	2007.0	3.132000e+01
368	United States of America	Population density	2012.0	3.202000e+01
369	United States of America	Population density	2015.0	3.273000e+01
370	United States of America	Gross Domestic Product (GDP)	1962.0	6.050000e+11
371	United States of America	Gross Domestic Product (GDP)	1967.0	8.620000e+11
372	United States of America	Gross Domestic Product (GDP)	1972.0	1.280000e+12
373	United States of America	Gross Domestic Product (GDP)	1977.0	2.090000e+12
374	United States of America	Gross Domestic Product (GDP)	1982.0	3.340000e+12
375	United States of America	Gross Domestic Product (GDP)	1987.0	4.870000e+12
376	United States of America	Gross Domestic Product (GDP)	1992.0	6.540000e+12
377	United States of America	Gross Domestic Product (GDP)	1997.0	8.610000e+12
378	United States of America	Gross Domestic Product (GDP)	2002.0	1.100000e+13
379	United States of America	Gross Domestic Product (GDP)	2007.0	1.450000e+13
380	United States of America	Gross Domestic Product (GDP)	2012.0	1.620000e+13
381	United States of America	Gross Domestic Product (GDP)	2015.0	1.790000e+13
382	United States of America	National Rainfall Index (NRI)	1965.0	9.285000e+02
383	United States of America	National Rainfall Index (NRI)	1969.0	9.522000e+02
384	United States of America	National Rainfall Index (NRI)	1974.0	1.008000e+03
385	United States of America	National Rainfall Index (NRI)	1981.0	9.492000e+02
386	United States of America	National Rainfall Index (NRI)	1984.0	9.746000e+02
387	United States of America	National Rainfall Index (NRI)	1992.0	1.020000e+03
388	United States of America	National Rainfall Index (NRI)	1996.0	1.005000e+03
389	United States of America	National Rainfall Index (NRI)	2002.0	9.387000e+02

390 rows × 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 [22]:
```
pd.unique(df1['Area'].tolist()), pd.unique(df1['Variable Name'].tolist()), pd.
unique(df1['Year'].tolist())
```

Out[22]:
```
(array(['Argentina', 'Australia', 'Germany', 'Iceland', 'Ireland', 'Sweden',
       'United States of America'], dtype=object),
 array(['Total area of the country', 'Total population',
       'Population density', 'Gross Domestic Product (GDP)',
       'National Rainfall Index (NRI)'], dtype=object),
 array([ 1962.,  1967.,  1972.,  1977.,  1982.,  1987.,  1992.,  1997.,
         2002.,  2007.,  2012.,  2014.,  2015.,  1963.,  1970.,  1974.,
         1978.,  1984.,  1990.,  1964.,  1981.,  1985.,  1996.,  2001.,
         1969.,  1973.,  1979.,  1993.,  1971.,  1975.,  1986.,  1991.,
         1998.,  2000.,  1965.,  1983.,  1988.,  1995.]))
```

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 [23]:
```
df1['Year'] = pd.to_datetime(pd.Series(df1['Year']).astype(int),format='%Y').d
t.year;
df1.tail()
```

Out[23]:

	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

Extracting Statistics

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

In [24]:
```
dftemp = df1[df1['Area']=='Iceland']; dftemp
```

Out[24]:

	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

	Area	Variable Name	Year	Value
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 [25]:
```
dftemp['Year'][dftemp['Variable Name']=='National Rainfall Index (NRI)'][dftemp['Value']>950], dftemp['Year'][dftemp['Variable Name']=='National Rainfall Index (NRI)'][dftemp['Value']<900]
```

Out[25]:
```
(215    1971
 216    1975
 218    1986
 219    1991
 220    1997
 Name: Year, dtype: int64, 214    1967
 Name: Year, dtype: int64)
```

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 [26]:
```
df_usa = df1[df1['Area']=='United States of America'];
df_usa = df_usa.set_index("Year", drop=False, verify_integrity = False)
df_usa
```

Out[26]:

	Area	Variable Name	Year	Value
Year				
1962	United States of America	Total area of the country	1962	9.629090e+05
1967	United States of America	Total area of the country	1967	9.629090e+05
1972	United States of America	Total area of the country	1972	9.629090e+05
1977	United States of America	Total area of the country	1977	9.629090e+05
1982	United States of America	Total area of the country	1982	9.629090e+05
1987	United States of America	Total area of the country	1987	9.629090e+05
1992	United States of America	Total area of the country	1992	9.629090e+05
1997	United States of America	Total area of the country	1997	9.629090e+05
2002	United States of America	Total area of the country	2002	9.632030e+05
2007	United States of America	Total area of the country	2007	9.632030e+05
2012	United States of America	Total area of the country	2012	9.831510e+05
2014	United States of America	Total area of the country	2014	9.831510e+05
1962	United States of America	Total population	1962	1.918610e+05
1967	United States of America	Total population	1967	2.037130e+05
1972	United States of America	Total population	1972	2.132200e+05
1977	United States of America	Total population	1977	2.230910e+05
1982	United States of America	Total population	1982	2.339540e+05
1987	United States of America	Total population	1987	2.454250e+05
1992	United States of America	Total population	1992	2.579080e+05
1997	United States of America	Total population	1997	2.728830e+05
2002	United States of America	Total population	2002	2.884710e+05
2007	United States of America	Total population	2007	3.016560e+05
2012	United States of America	Total population	2012	3.147990e+05
2015	United States of America	Total population	2015	3.217740e+05
1962	United States of America	Population density	1962	1.993000e+01
1967	United States of America	Population density	1967	2.116000e+01
1972	United States of America	Population density	1972	2.214000e+01
1977	United States of America	Population density	1977	2.317000e+01
1982	United States of America	Population density	1982	2.430000e+01
1987	United States of America	Population density	1987	2.549000e+01
1992	United States of America	Population density	1992	2.678000e+01

	Area	Variable Name	Year	Value
Year				
1997	United States of America	Population density	1997	2.834000e+01
2002	United States of America	Population density	2002	2.995000e+01
2007	United States of America	Population density	2007	3.132000e+01
2012	United States of America	Population density	2012	3.202000e+01
2015	United States of America	Population density	2015	3.273000e+01
1962	United States of America	Gross Domestic Product (GDP)	1962	6.050000e+11
1967	United States of America	Gross Domestic Product (GDP)	1967	8.620000e+11
1972	United States of America	Gross Domestic Product (GDP)	1972	1.280000e+12
1977	United States of America	Gross Domestic Product (GDP)	1977	2.090000e+12
1982	United States of America	Gross Domestic Product (GDP)	1982	3.340000e+12
1987	United States of America	Gross Domestic Product (GDP)	1987	4.870000e+12
1992	United States of America	Gross Domestic Product (GDP)	1992	6.540000e+12
1997	United States of America	Gross Domestic Product (GDP)	1997	8.610000e+12
2002	United States of America	Gross Domestic Product (GDP)	2002	1.100000e+13
2007	United States of America	Gross Domestic Product (GDP)	2007	1.450000e+13
2012	United States of America	Gross Domestic Product (GDP)	2012	1.620000e+13
2015	United States of America	Gross Domestic Product (GDP)	2015	1.790000e+13
1965	United States of America	National Rainfall Index (NRI)	1965	9.285000e+02
1969	United States of America	National Rainfall Index (NRI)	1969	9.522000e+02
1974	United States of America	National Rainfall Index (NRI)	1974	1.008000e+03
1981	United States of America	National Rainfall Index (NRI)	1981	9.492000e+02
1984	United States of America	National Rainfall Index (NRI)	1984	9.746000e+02
1992	United States of America	National Rainfall Index (NRI)	1992	1.020000e+03
1996	United States of America	National Rainfall Index (NRI)	1996	1.005000e+03
2002	United States of America	National Rainfall Index (NRI)	2002	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 [27]:
```
df_usa=df_usa.pivot(columns='Variable Name',values='Value')
df_usa.head()
```

Out[27]:

Variable Name	Gross Domestic Product (GDP)	National Rainfall Index (NRI)	Population density	Total area of the country	Total 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

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

In [28]:
```
df_usa = df_usa.rename(columns = {'Gross Domestic Product (GDP)':'GDP', 'Natio
nal Rainfall Index (NRI)':'NRI', 'Population density': 'PD', 'Total area of th
e country':'Area', 'Total population':'Population'});
df_usa
```

Out[28]:

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 [29]:
```
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 [30]:
```
df_usa.describe().loc[['mean', 'std']]
```

Out[30]:

Variable Name	GDP	NRI	PD	Area	Population
mean	4.620895e+12	409.273684	16.701579	610314.736842	161513.421053
std	6.088656e+12	493.551503	13.554620	478948.168858	131380.538153

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 [31]:
```
df_usa.loc[:,['Area']]*=10;df_usa
```

Out[31]:

Variable Name	GDP	NRI	PD	Area	Population
Year					
1962	6.050000e+11	0.0	19.93	9629090.0	191861.0
1965	0.000000e+00	928.5	0.00	0.0	0.0
1967	8.620000e+11	0.0	21.16	9629090.0	203713.0
1969	0.000000e+00	952.2	0.00	0.0	0.0
1972	1.280000e+12	0.0	22.14	9629090.0	213220.0
1974	0.000000e+00	1008.0	0.00	0.0	0.0
1977	2.090000e+12	0.0	23.17	9629090.0	223091.0
1981	0.000000e+00	949.2	0.00	0.0	0.0
1982	3.340000e+12	0.0	24.30	9629090.0	233954.0
1984	0.000000e+00	974.6	0.00	0.0	0.0
1987	4.870000e+12	0.0	25.49	9629090.0	245425.0
1992	6.540000e+12	1020.0	26.78	9629090.0	257908.0
1996	0.000000e+00	1005.0	0.00	0.0	0.0
1997	8.610000e+12	0.0	28.34	9629090.0	272883.0
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 [32]:
```
df_usa['GDP/capita'] = (df_usa['GDP']/df_usa['Population']).round(2); df_usa
```

Out[32]:

Variable Name	GDP	NRI	PD	Area	Population	GDP/capita
Year						
1962	6.050000e+11	0.0	19.93	9629090.0	191861.0	3153324.54
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	4231443.26
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	6003189.19
1974	0.000000e+00	1008.0	0.00	0.0	0.0	NaN
1977	2.090000e+12	0.0	23.17	9629090.0	223091.0	9368374.34
1981	0.000000e+00	949.2	0.00	0.0	0.0	NaN
1982	3.340000e+12	0.0	24.30	9629090.0	233954.0	14276310.73
1984	0.000000e+00	974.6	0.00	0.0	0.0	NaN
1987	4.870000e+12	0.0	25.49	9629090.0	245425.0	19843129.27
1992	6.540000e+12	1020.0	26.78	9629090.0	257908.0	25357879.55
1996	0.000000e+00	1005.0	0.00	0.0	0.0	NaN
1997	8.610000e+12	0.0	28.34	9629090.0	272883.0	31551983.82
2002	1.100000e+13	938.7	29.95	9632030.0	288471.0	38132082.60
2007	1.450000e+13	0.0	31.32	9632030.0	301656.0	48067997.98
2012	1.620000e+13	0.0	32.02	9831510.0	314799.0	51461408.71
2014	0.000000e+00	0.0	0.00	9831510.0	0.0	NaN
2015	1.790000e+13	0.0	32.73	0.0	321774.0	55629106.14

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 [33]:
```
df_usa['PD2'] = (df_usa['Population']*1000/df_usa['Area']).round(2); df_usa
```

Out[33]:

Variable Name	GDP	NRI	PD	Area	Population	GDP/capita	PD2
Year							
1962	6.050000e+11	0.0	19.93	9629090.0	191861.0	3153324.54	19.930000
1965	0.000000e+00	928.5	0.00	0.0	0.0	NaN	NaN
1967	8.620000e+11	0.0	21.16	9629090.0	203713.0	4231443.26	21.160000
1969	0.000000e+00	952.2	0.00	0.0	0.0	NaN	NaN
1972	1.280000e+12	0.0	22.14	9629090.0	213220.0	6003189.19	22.140000
1974	0.000000e+00	1008.0	0.00	0.0	0.0	NaN	NaN
1977	2.090000e+12	0.0	23.17	9629090.0	223091.0	9368374.34	23.170000
1981	0.000000e+00	949.2	0.00	0.0	0.0	NaN	NaN
1982	3.340000e+12	0.0	24.30	9629090.0	233954.0	14276310.73	24.300000
1984	0.000000e+00	974.6	0.00	0.0	0.0	NaN	NaN
1987	4.870000e+12	0.0	25.49	9629090.0	245425.0	19843129.27	25.490000
1992	6.540000e+12	1020.0	26.78	9629090.0	257908.0	25357879.55	26.780000
1996	0.000000e+00	1005.0	0.00	0.0	0.0	NaN	NaN
1997	8.610000e+12	0.0	28.34	9629090.0	272883.0	31551983.82	28.340000
2002	1.100000e+13	938.7	29.95	9632030.0	288471.0	38132082.60	29.950000
2007	1.450000e+13	0.0	31.32	9632030.0	301656.0	48067997.98	31.320000
2012	1.620000e+13	0.0	32.02	9831510.0	314799.0	51461408.71	32.020000
2014	0.000000e+00	0.0	0.00	9831510.0	0.0	NaN	0.000000
2015	1.790000e+13	0.0	32.73	0.0	321774.0	55629106.14	inf

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 [34]:
```
# df_usa.describe().loc[:,['NRI']].loc[['min','max']]
# df1['Year'][df_usa['NRI'].idxmin()], df1['Year'][df_usa['NRI'].idxmax()]
print("Max", df_usa.NRI.max(), df_usa.NRI.idxmax(), " | ", "Min", df_usa[df_us
a["NRI"]>0].NRI.min(), df_usa[df_usa["NRI"]>0].NRI.idxmin())
```

```
Max 1020.0 1992  |  Min 928.5 1965
```

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`.

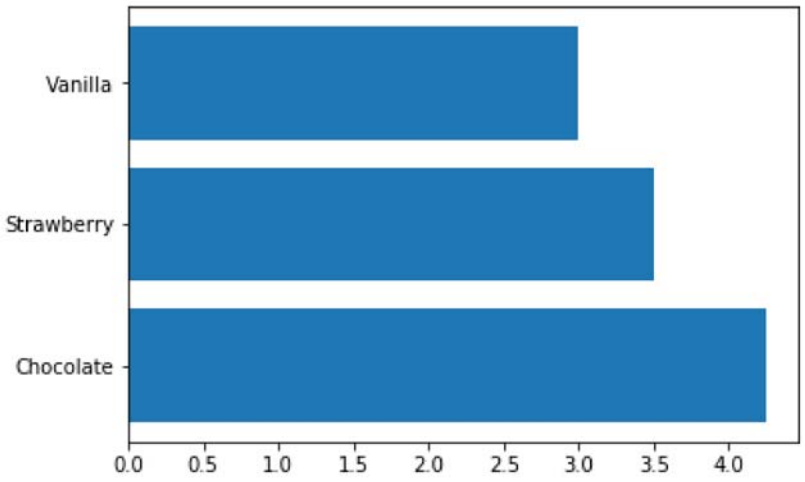
In [35]:
```
Flavor = ['Strawberry', 'Vanilla', 'Chocolate']; print(Flavor)
Price = [3.50,3.00,4.25]; print(Price)
dict1 = {'Flavor':Flavor, 'Price': Price}
icecream = pd.DataFrame(dict1); print(icecream)
```

```
['Strawberry', 'Vanilla', 'Chocolate']
[3.5, 3.0, 4.25]
       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 [36]:
```
plt.barh(icecream['Flavor'],icecream['Price'])
```

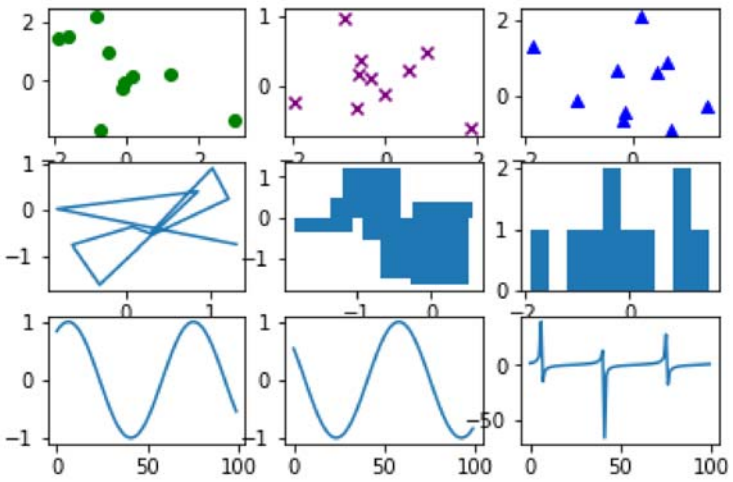
Out[36]: `<Container object of 3 artists>`



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 [37]:
```
f, ax = plt.subplots(nrows=3,ncols=3)
ax[0,0].scatter(np.random.randn(10),np.random.randn(10), color='green')
ax[0,1].scatter(np.random.randn(10),np.random.randn(10), color='purple',marker
="x" )
ax[0,2].scatter(np.random.randn(10),np.random.randn(10), color='blue',marker=
"^" )
ax[1,0].plot(np.random.randn(10),np.random.randn(10))
ax[1,1].bar(np.random.randn(10),np.random.randn(10))
ax[1,2].hist(np.random.randn(10))
ax[2,0].plot(np.sin(np.linspace(1,10,100)))
ax[2,1].plot(np.cos(np.linspace(1,10,100)))
ax[2,2].plot(np.tan(np.linspace(1,10,100)))
```

Out[37]: [<matplotlib.lines.Line2D at 0x1dbc3f93780>]



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 (https://www.quantshare.com/sa-43-10-ways-to-download-historical-stock-quotes-data-for-free)

In [38]:
```
df_google = pd.read_csv('https://finance.google.com/finance/historical?output=csv&q=goog')
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[38]:

	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 [39]:
```
df_disney['Date'] = pd.to_datetime(df_disney['Date'],infer_datetime_format=True) # set index
df_disney.set_index("Date", inplace=True)
df_disney.head()
df_apple['Date'] = pd.to_datetime(df_apple['Date'],infer_datetime_format=True)
 # set index
df_apple.set_index("Date", inplace=True)
df_apple.head()
df_nike['Date'] = pd.to_datetime(df_nike['Date'],infer_datetime_format=True) #
 set index
df_nike.set_index("Date", inplace=True)
df_nike.head()


df_close = pd.DataFrame({"Nike":df_nike.Close,"Apple": df_apple.Close, "Disne
y": df_disney.Close})
df_close.head()
df_close["2017-07"].corr()
```

Out[39]:

	Apple	Disney	Nike
Apple	1.000000	0.524912	0.417947
Disney	0.524912	1.000000	0.459045
Nike	0.417947	0.459045	1.000000

Show the same correlation matrix but over different time periods.

1. the last 20 days
2. the last 80 days

In [40]:
```
df_disney.head(), df_apple.head(), df_nike.head()
since_20 = pd.datetime.fromtimestamp(pd.datetime.today().timestamp() - 20*8640
0)
since_80 = pd.datetime.fromtimestamp(pd.datetime.today().timestamp() - 80*8640
0)

df_close_20 = df_close[df_close.index>since_20]
df_close_20.corr()
```

Out[40]:

	Apple	Disney	Nike
Apple	1.000000	0.847461	0.702321
Disney	0.847461	1.000000	0.900179
Nike	0.702321	0.900179	1.000000

In [41]:
```
df_close_80 = df_close[df_close.index>since_80]
df_close_80.corr()
```

Out[41]:

	Apple	Disney	Nike
Apple	1.000000	0.440883	-0.061922
Disney	0.440883	1.000000	0.659349
Nike	-0.061922	0.659349	1.000000

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.

In [42]:
```
# Define stock list here
stocks = ['NKE', 'AAPL','DIS', 'GOOGL']

since_100 = pd.datetime.fromtimestamp(pd.datetime.today().timestamp() - 100*86
400)

df_master = [pd.read_csv('https://finance.google.com/finance/historical?output
=csv&q='+x) for x in stocks]
# df_master = [pd.to_datetime(x['Date'],infer_datetime_format=True) for x in d
f_master]
for df in df_master:
     df['Date'] = pd.to_datetime(df['Date'],infer_datetime_format=True)

df_master_close = [x['Close'][x['Date'][x['Date'].index] >=since_100] for x in
 df_master]
df_master_close = pd.DataFrame([df_master_close[stocks.index(x)].rename(x) for
 x in stocks])
df_master_close.T.corr()
```

Out[42]:

	NKE	AAPL	DIS	GOOGL
NKE	1.000000	-0.076929	0.818333	0.756887
AAPL	-0.076929	1.000000	0.290307	0.214503
DIS	0.818333	0.290307	1.000000	0.659220
GOOGL	0.756887	0.214503	0.659220	1.000000