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 [8]:
```
import math
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 [10]:
```
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  4.333
33333
  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 [11]:
```
sq_a = np.square(a)
sq_b = np.square(b)
sum_ab = np.add(sq_a, sq_b)
even_total = 0
for i in range(len(sum_ab)):
    if i%2 == 0:
        even_total += sum_ab[i]
sqrt_ab = np.sqrt(sum_ab)

print("1. ", sq_a, sq_b )
print("2. ", sum_ab)
print("3. ", even_total)
print("4. ", sqrt_ab)
```

```
1.  [100 121 144 169 196 225 256 289 324 361] [  1.           2.7777777
8   5.44444444   9.          13.44444444
  18.77777778  25.          32.11111111  40.11111111  49.        ]
2.  [ 101.         123.77777778  149.44444444  178.         209.44444
444
  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 [12]:
```
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 [13]:
```
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 [14]:
```
m3 = np.matmul(m2.transpose(), 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 [15]:
```
m3 = np.round(m3, 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 [16]:
```
sorted_m3 = np.sort(m3)

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

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

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 [17]:
```
f = np.linspace(0, math.pi, 100)
f = np.sin(f)

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

```
f:  [  0.00000000e+00   3.17279335e-02   6.34239197e-02   9.50560433e-0
2
   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 [18]:
```
m = [elem >= 0.5 for elem in f]
f[m]
```

Out[18]:
```
array([ 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 [19]: # 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 [20]:
```
ex_x = np.mean(x)
ex_y = np.mean(y)

print ('expected value of x = ', ex_x)
print ('expected value of y = ', ex_y)
```

```
expected value of x =  5.78253254159
expected value of y =  11.0129816833
```

Find the variance for x and y.

In [21]:
```
var_x = np.var(x)
var_y = np.var(y)

print ('Variance of x = ', ex_x)
print ('Variance of y = ', ex_y)
```

```
Variance of x =  5.78253254159
Variance of y =  11.0129816833
```

Find the co-variance of x and y.

In [22]:
```
cov_xy = np.cov(x, y)

print('Covariance of x and y = ', cov_xy)
```

```
Covariance of x and y =  [[  7.10437124  14.65774383]
 [ 14.65774383  30.41808442]]
```

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 [24]:
```
A = np.vstack([x, np.ones(len(x))]).transpose()
result = np.linalg.lstsq(A, y)
m, b = result[0]

y_predicted = str(m) + 'x + ' + str(b)
print(y_predicted)
```

```
2.06320071597x + -0.917543596587
```

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

```
In [25]: predict = m*x + b
         y_error = y - predict

         print(y_error)
```

```
[-0.19775597  0.62457111 -0.10030076 -0.02506341 -0.02083649  0.4671682
3
  0.24499418  0.53440482 -0.24466541  0.21408918 -0.50209852 -0.2777502
9
  0.06213923  0.42578118  0.0931215  -0.86405311  0.1157489  -0.3155838
8
 -0.62666017 -0.40166149 -0.46107377 -0.47954311 -0.3607047  -0.1783890
4
 -0.58942116 -0.10891094  0.07115518 -0.29032384  0.74232081  0.1908286
3
 -0.35553767 -0.14062095  0.39304511  0.0567791   0.61328502  0.8031067
6
  0.77597321  0.12176065 -0.06373323 -0.26383402 -0.45927925 -0.1234723
8
 -0.60673379 -0.20079382  0.0660562  -0.30670405  0.33067419 -0.062778
  0.75987212 -0.67596798  0.65468531 -0.02820071 -0.08606832  0.2617114
3
  0.72997592  0.60306068 -0.40563939 -0.05397013  0.02061681 -0.2854892
8
  0.7405245  -0.58908804 -0.43343988  0.76182107  0.02727604  0.3256440
1
  0.56606805  0.11129392 -0.46417555  0.27572093 -0.5147747  -0.1686214
2
 -0.42262995  0.08035574 -0.72551112  0.43596616 -0.71282602  0.1102733
7
  0.16964259 -0.14132301 -0.58920807  0.31716141 -0.17248631  0.7399727
8
 -0.16712997 -0.17284167  0.33165948  0.52075457  0.43302563 -0.6359709
 -0.30175553 -0.10998314  0.29405306 -0.07784496 -0.00668554 -0.0464643
1
 -0.07609646  0.06370343  0.79862812 -0.38799477]
```

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

```
In [26]: rmse = np.sqrt(np.sum(y_error**2))
         print('RSME:', rmse)
```

```
RSME: 4.17677723669
```

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 [27]:
```
df = df = pd.read_csv('data3.csv')
df.head(10)
```

Out[27]:

	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 [28]:
```
print(df.columns)
```

```
Index(['Area', 'Area Id', 'Variable Name', 'Variable Id', 'Year', 'Valu
e',
       '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 [29]:
```
df.isnull().tail()
df.drop(['Md'], axis=1)
df = df[:-8]
```

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 [47]:
```
df1 = df.drop(['Area Id', 'Variable Id', 'Symbol', 'Md'], axis=1)
df1.head()
```

Out[47]:

	Area	Variable Name	Year	Value
0	Argentina	Total area of the country	1962.0	278040.0
1	Argentina	Total area of the country	1967.0	278040.0
2	Argentina	Total area of the country	1972.0	278040.0
3	Argentina	Total area of the country	1977.0	278040.0
4	Argentina	Total area of the country	1982.0	278040.0

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 [31]:
```
for name in ['Area', 'Variable Name', 'Year']:
    print(df1[name].unique(), "\n")
```

```
['Argentina' 'Australia' 'Germany' 'Iceland' 'Ireland' 'Sweden'
 'United States of America']

['Total area of the country' 'Total population' 'Population density'
 'Gross Domestic Product (GDP)' 'National Rainfall Index (NRI)']

[ 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 [32]:
```
df1['Year'] = pd.to_datetime(pd.Series(df1['Year']).astype(int),format=
'%Y').dt.year
df1.tail()
```

Out[32]:

	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 [33]:
```
dftemp = df1[df1['Area'] == 'Iceland']
dftemp.head()
```

Out[33]:

	Area	Variable Name	Year	Value
166	Iceland	Total area of the country	1962	10300.0
167	Iceland	Total area of the country	1967	10300.0
168	Iceland	Total area of the country	1972	10300.0
169	Iceland	Total area of the country	1977	10300.0
170	Iceland	Total area of the country	1982	10300.0

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 [34]:
```
dftemp[(dftemp['Variable Name'] == 'National Rainfall Index (NRI)')
        & ((dftemp['Value'] > 950) | (dftemp['Value'] < 900))]
```

Out[34]:

	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 [35]:
```
df_usa = df1[df1['Area'] == 'United States of America'].set_index('Year'
)
df_usa.head()
```

Out[35]:

	Area	Variable Name	Value
Year			
1962	United States of America	Total area of the country	962909.0
1967	United States of America	Total area of the country	962909.0
1972	United States of America	Total area of the country	962909.0
1977	United States of America	Total area of the country	962909.0
1982	United States of America	Total area of the country	962909.0

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 [36]:
```
df_usa = df_usa.pivot(columns='Variable Name',values='Value')
df_usa.head()
```

Out[36]:

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 [37]:
```
df_usa.columns = ['GDP','NRI','PD','Area','Population']
df_usa.head()
```

Out[37]:

	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

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 [38]:
```
print("Number of NAN values before:\n", df_usa.isnull().sum())

df_usa=df_usa.fillna(0)
print("Number of NAN values after:\n ", df_usa.isnull().sum())
```

```
Number of NAN values before:
 GDP            7
NRI           11
PD             7
Area           7
Population     7
dtype: int64
Number of NAN values after:
  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 [39]:
```
df_usa.describe()
```

Out[39]:

	GDP	NRI	PD	Area	Population
count	1.900000e+01	19.000000	19.000000	19.000000	19.000000
mean	4.620895e+12	409.273684	16.701579	610314.736842	161513.421053
std	6.088656e+12	493.551503	13.554620	478948.168858	131380.538153
min	0.000000e+00	0.000000	0.000000	0.000000	0.000000
25%	0.000000e+00	0.000000	0.000000	0.000000	0.000000
50%	1.280000e+12	0.000000	22.140000	962909.000000	213220.000000
75%	7.575000e+12	950.700000	27.560000	962909.000000	265395.500000
max	1.790000e+13	1020.000000	32.730000	983151.000000	321774.000000

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 [40]:
```
df_usa['Area'] = df_usa['Area']*10
df_usa.head()
```

Out[40]:

	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

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 [41]:
```
df_usa['GDP/capita'] = (df_usa['GDP']/df_usa['Population']).round(2)
df_usa.head()
```

Out[41]:

	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

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 [42]:
```
df_usa['PD2'] = df_usa['Population']/df_usa['Area'].round(2)
df_usa.head()
```

Out[42]:

	GDP	NRI	PD	Area	Population	GDP/capita	PD2
Year							
1962	6.050000e+11	0.0	19.93	9629090.0	191861.0	3153324.54	0.019925
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	0.021156
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	0.022143

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 [43]:
```
print('Year of min NRI: =', df_usa['NRI'].idxmin())
print('Year of max MRI: =', df_usa['NRI'].idxmax())
```

```
Year of min NRI: = 1962
Year of max MRI: = 1992
```

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`.

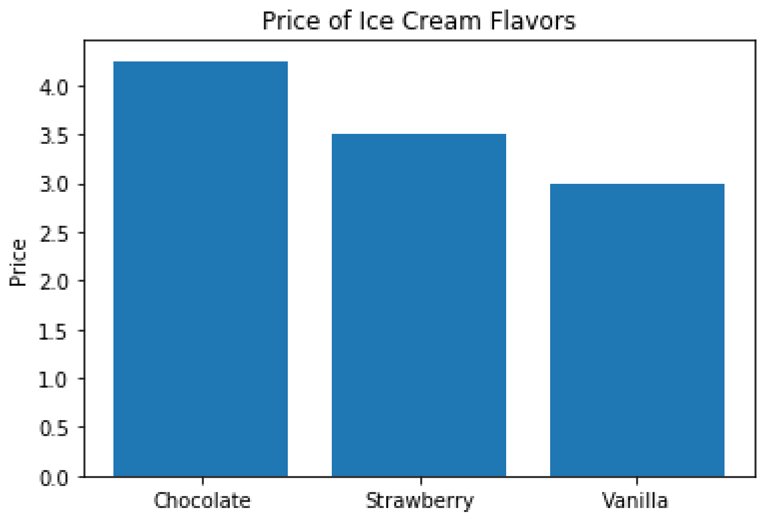
In [44]:
```
data = {'Flavor': ['Strawberry', 'Vanilla', 'Chocolate'], 'Price': [3.50
, 3.00, 4.25]}
icecream = pd.DataFrame(data)
icecream
```

Out[44]:

	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.

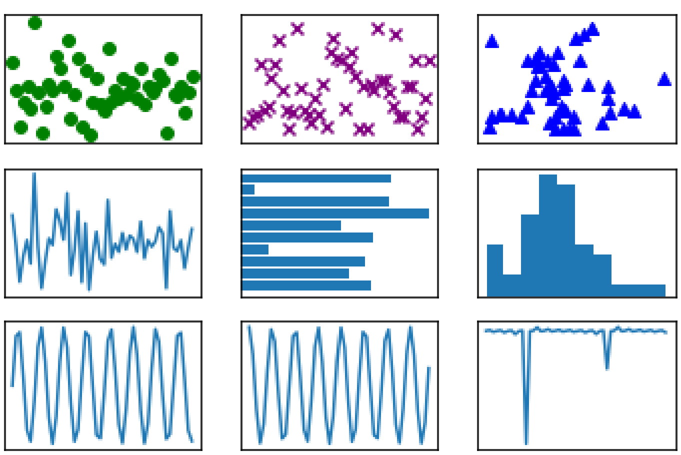
In [45]:
```
plt.bar(icecream['Flavor'], icecream['Price'])
plt.ylabel('Price')
plt.title('Price of Ice Cream Flavors')

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 [46]:

```
import random

data = {'col1': np.arange(0, 50), 'col2': np.random.normal(10, .41, 50),
 'col3': np.random.beta(2, 3, 50), }
plot_data = pd.DataFrame(data)
bar_data = pd.DataFrame({'Names': ['one', 'two', 'three'], 'Values' : [5
, 10, 4]})

def hide_labels():
    return plt.xticks([]), plt.yticks([])

#row 1
plt.subplot(331)
plt.scatter(data['col1'], data['col2'], color='green', ); hide_labels()
plt.subplot(332)
plt.scatter(data['col1'], data['col3'], color='purple', marker='x'); hid
e_labels()
plt.subplot(333)
plt.scatter(data['col2'], data['col3'], color='blue', marker='^'); hide_
labels()

#row 2
plt.subplot(334)
plt.plot(data['col1'], data['col2']); hide_labels()
plt.subplot(335)
plt.barh(np.arange(0,10), random.sample(range(100), 10)); hide_labels()
plt.subplot(336)
plt.hist(data['col2']); hide_labels()

#row3
plt.subplot(337)
plt.plot(data['col1'], np.sin(data['col1'])); hide_labels()
plt.subplot(338)
plt.plot(data['col1'], np.cos(data['col1'])); hide_labels()
plt.subplot(339)
plt.plot(data['col1'], np.tan(data['col1'])); hide_labels()

plt.show()
```



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 [ ]:
```
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()
```

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().

Show the same correlation matrix but over different time periods.

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

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.