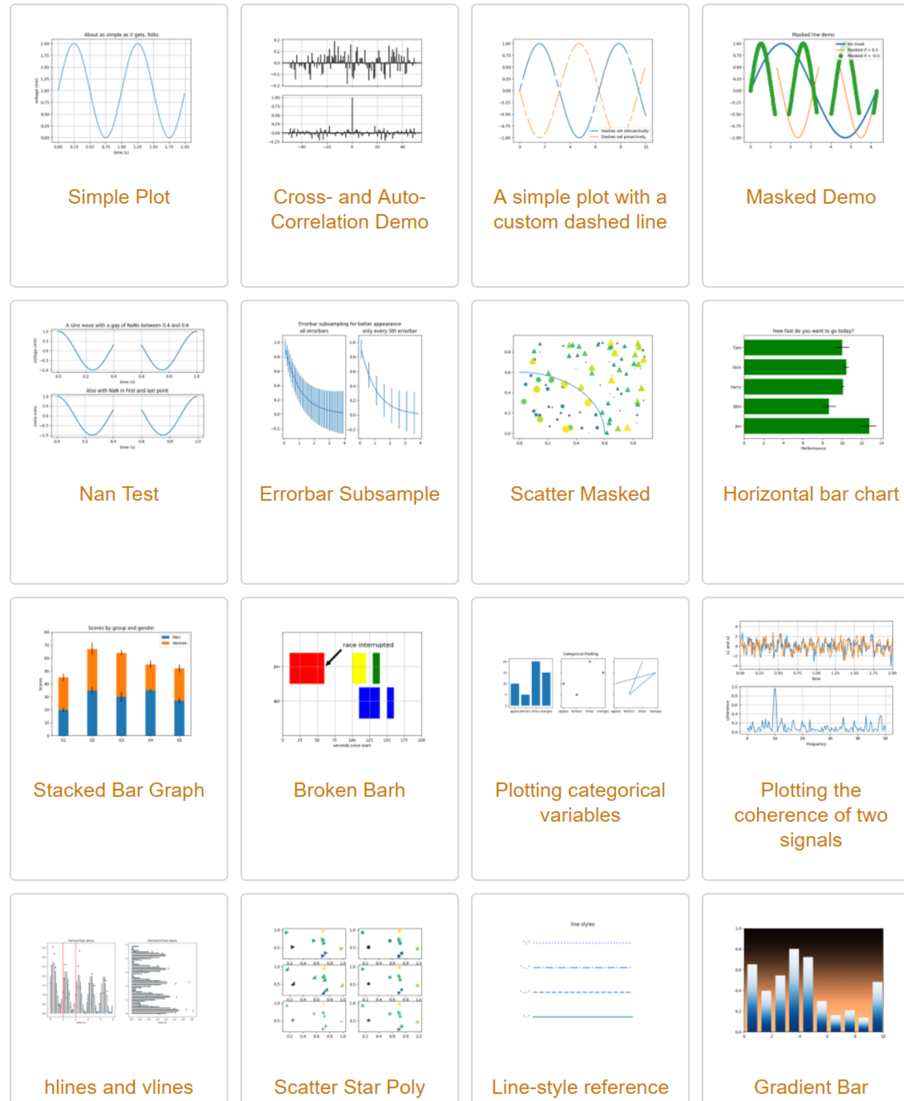
4. Matplotlib + Pandas

Spring 2018

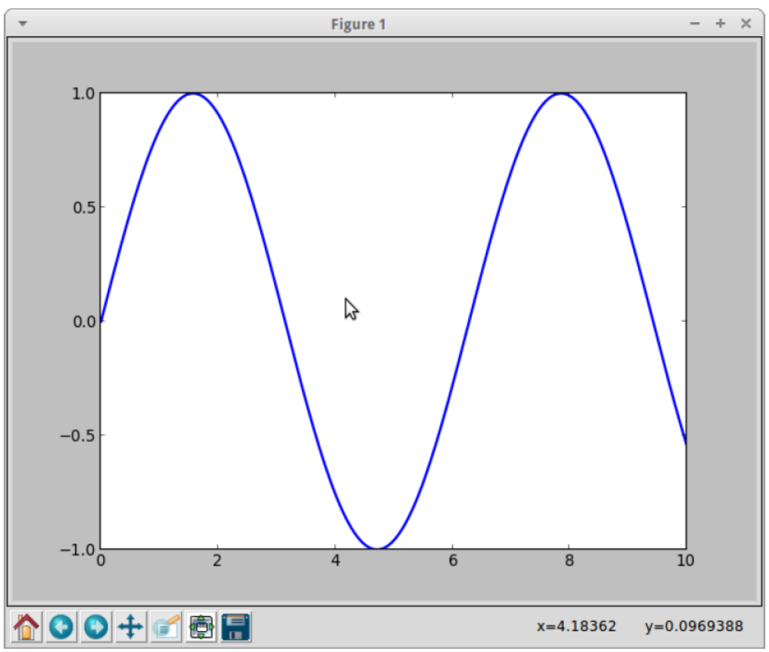
Intro to Matplotlib

- Overview
  - https://matplotlib.org
  - 2D and 3D plots



Intro to Matplotlib

```
import matplotlib.pyplot as plt
import numpy as np
x = np.linspace(0, 10, 200)
y = np.sin(x)
plt.plot(x, y, 'b-', linewidth=2)
plt.show()
```



- More Pythonic
  - Explicit style of programming

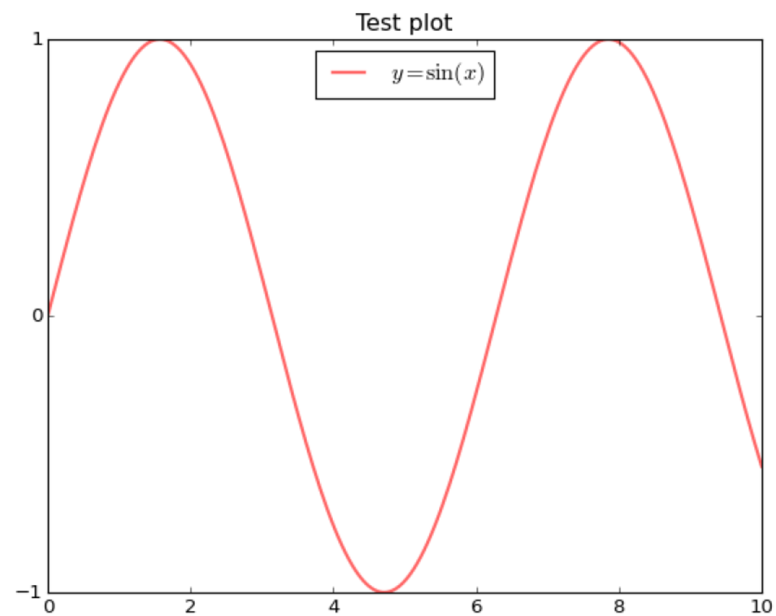
```
import matplotlib.pyplot as plt
import numpy as np
fig, ax = plt.subplots()
x = np.linspace(0, 10, 200)
y = np.sin(x)
ax.plot(x, y, 'b-', linewidth=2)
plt.show()
```

- fig is a Figure instance – like a blank canvas
- ax is an AxesSubplot instance
- plot() function is actually a method of ax

Something more

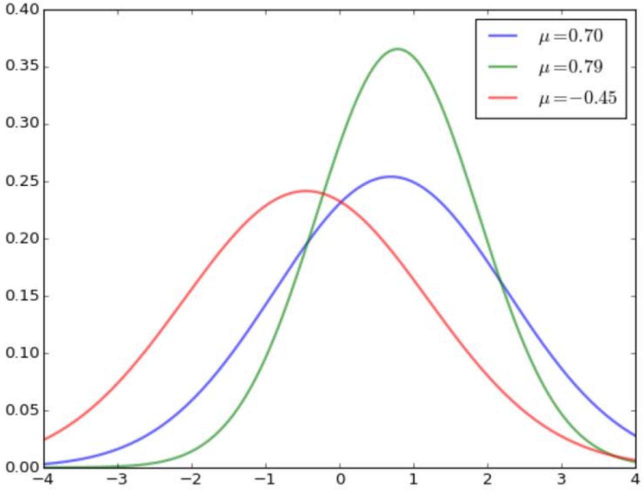
```
import matplotlib.pyplot as plt
import numpy as np
fig, ax = plt.subplots()
x = np.linspace(0, 10, 200)
y = np.sin(x)
ax.plot(x, y, 'r-', linewidth=2, label=r'$y=\sin(x)$', alpha=0.6)
ax.legend(loc='upper center')
ax.set_yticks([-1, 0, 1])
ax.set_title('Test plot')
plt.show()
```

- Title
- linewidth
- label & legend
- LaTeX

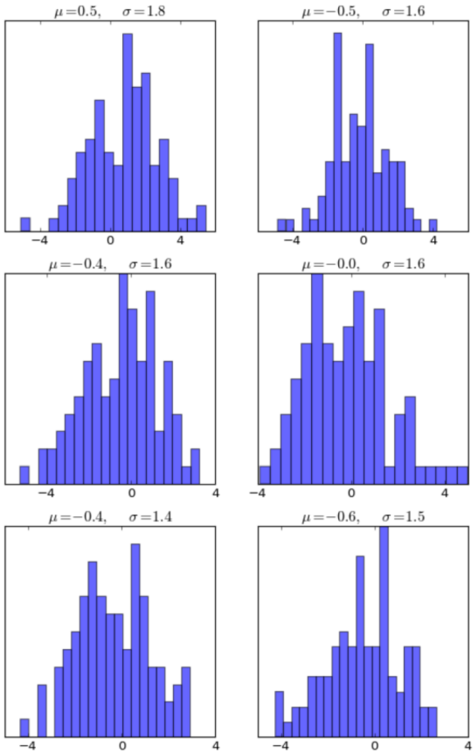


Multiple Plots on One Axis

```
import matplotlib.pyplot as plt
import numpy as np
from scipy.stats import norm
from random import uniform

fig, ax = plt.subplots()
x = np.linspace(-4, 4, 150)
for i in range(3):
    m, s = uniform(-1, 1), uniform(1, 2)
    y = norm.pdf(x, loc=m, scale=s)
    current_label = r'$\mu = {0:.2f}$'.format(m)
    ax.plot(x, y, linewidth=2, alpha=0.6, label=current_label)
ax.legend()
plt.show()
```



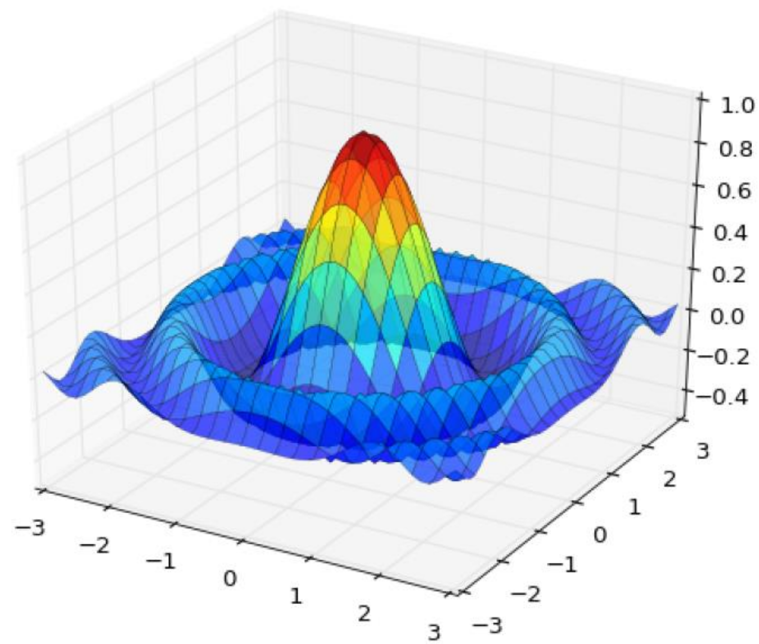
Multiple Subplot




```python
import matplotlib.pyplot as plt
from scipy.stats import norm
from random import uniform
num_rows, num_cols = 3, 2
fig, axes = plt.subplots(num_rows, num_cols, figsize=(8, 12))
for i in range(num_rows):
    for j in range(num_cols):
        m, s = uniform(-1, 1), uniform(1, 2)
        x = norm.rvs(loc=m, scale=s, size=100)
        axes[i, j].hist(x, alpha=0.6, bins=20)
        t = r'$\mu = {0:.1f}, \quad \sigma = {1:.1f}$'.format(m, s)
        axes[i, j].set_title(t)
        axes[i, j].set_xticks([-4, 0, 4])
        axes[i, j].set_yticks([])
plt.show()
```

3D Plots

```
import matplotlib.pyplot as plt
from mpl_toolkits.mplot3d.axes3d import Axes3D
import numpy as np
from matplotlib import cm


def f(x, y):
    return np.cos(x**2 + y**2) / (1 + x**2 + y**2)

xgrid = np.linspace(-3, 3, 50)
ygrid = xgrid
x, y = np.meshgrid(xgrid, ygrid)

fig = plt.figure(figsize=(8, 6))
ax = fig.add_subplot(111, projection='3d')
ax.plot_surface(x,
                y,
                f(x, y),
                rstride=2, cstride=2,
                cmap=cm.jet,
                alpha=0.7,
                linewidth=0.25)
ax.set_zlim(-0.5, 1.0)
plt.show()
```



Overview

- What is pandas?
  - A package of fast, efficient data analysis tools for Python
  - DataFrame object for data manipulation with integrated indexing

- Strengths of pandas
  - Reading in data
  - Reshaping and pivoting of data sets
  - Manipulating rows and columns
  - Adjusting indices
  - Working with dates and time-series
  - Sorting, grouping, re-ordering and general data merging
  - Dealing with missing values

Series

- "column" of data
- Collection of observations on a single variable

```
In [1]: import pandas as pd

In [2]: import numpy as np

In [4]: s = pd.Series(np.random.randn(4), name='daily returns')
```

```
In [5]: s
Out[5]:
0     0.430271
1     0.617328
2    -0.265421
3    -0.836113
Name: daily returns
```

```
In [6]: s * 100
Out[6]:
0     43.027108
1     61.732829
2    -26.542104
3    -83.611339
Name: daily returns
```

```
In [7]: np.abs(s)
Out[7]:
0     0.430271
1     0.617328
2     0.265421
3     0.836113
Name: daily returns
```

More than NumPy Arrays

```
In [9]: s.index = ['AMZN', 'AAPL', 'MSFT', 'GOOG']

In [10]: s
Out[10]:
AMZN    0.430271
AAPL    0.617328
MSFT   -0.265421
GOOG   -0.836113
Name: daily returns

In [8]: s.describe()
Out[8]:
count     4.000000
mean     -0.013484
std       0.667092
min      -0.836113
25%      -0.408094
50%       0.082425
75%       0.477035
max       0.617328
```

```
In [11]: s['AMZN']
Out[11]: 0.43027108469945924

In [12]: s['AMZN'] = 0

In [13]: s
Out[13]:
AMZN    0.000000
AAPL    0.617328
MSFT   -0.265421
GOOG   -0.836113
Name: daily returns

In [14]: 'AAPL' in s
Out[14]: True
```

DataFrame

- DataFrame
  - Object for storing related columns of data
  - Analogous to a Excel spreadsheet

```
In [28]: df = pd.read_csv('data/test_pwt.csv')

In [29]: type(df)
Out[29]: pandas.core.frame.DataFrame

In [30]: df
Out[30]:
       country country isocode  year         POP       XRA
0    Argentina             ARG  2000   37335.653   0.99950
1    Australia             AUS  2000   19053.186   1.72483
2        India             IND  2000 1006300.297  44.94160
3       Israel             ISR  2000    6114.570   4.07733
4       Malawi             MWI  2000   11801.505  59.54380
5 South Africa             ZAF  2000   45064.098   6.93983
6 United States            USA  2000  282171.957   1.00000
7      Uruguay             URY  2000    3219.793  12.09959
```

DataFrame Slicing

```
In [13]: df[2:5]
Out[13]:
  country country isocode  year          POP      XRAT          tc
2   India             IND  2000  1006300.297  44.941600  1728144.374
3  Israel             ISR  2000     6114.570   4.077330   129253.894
4  Malawi             MWI  2000    11801.505  59.543808     5026.221
```

```
In [14]: df[['country', 'tcgdp']]
Out[14]:
         country           tcgdp
0      Argentina   295072.218690
1      Australia   541804.652100
2          India  1728144.374800
3         Israel   129253.894230
4         Malawi     5026.221784
5   South Africa   227242.369490
6  United States  9898700.000000
7        Uruguay    25255.961693
```

Data Handling

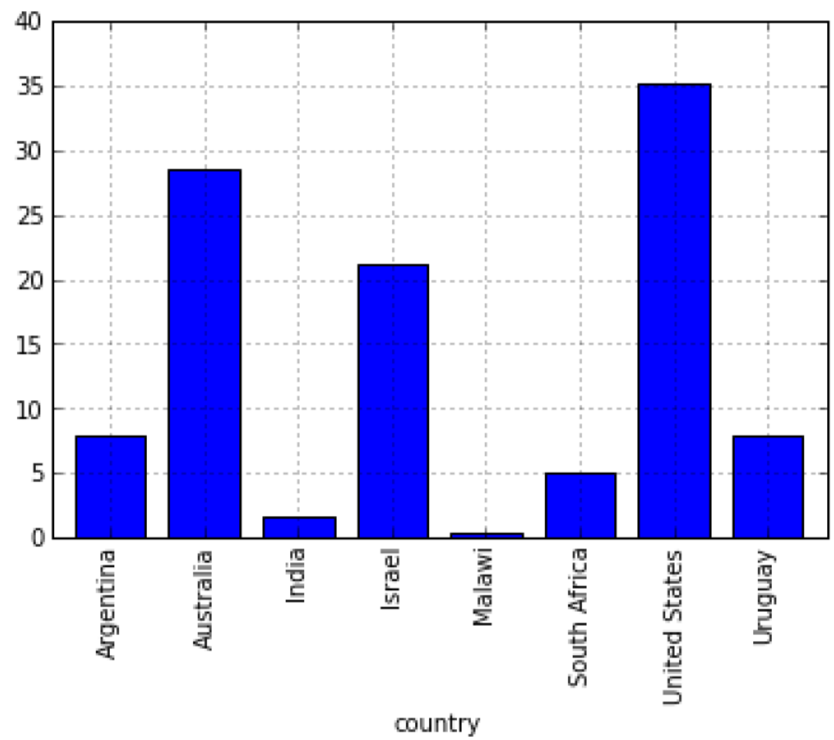
```
In [31]: keep = ['country', 'POP', 'tcgdp']

In [32]: df = df[keep]

In [34]: countries = df.pop('country')

In [38]: df.index = countries

In [40]: df.columns = 'population', 'total GDP'

In [66]: df['population'] = df['population'] * 1e3

In [74]: df['GDP percap'] = df['total GDP'] * 1e6 / df['population']

In [75]: df
Out[75]:
               population    total GDP   GDP percap
country
Argentina        37335653   295072.218690   7903.229085
Australia        19053186   541804.652100  28436.433261
India          1006300297  1728144.374800   1717.324719
Israel            6114570   129253.894230  21138.672749
Malawi           11801505     5026.221784    425.896679
South Africa     45064098   227242.369490   5042.647686
United States   282171957  9898700.000000  35080.381854
Uruguay           3219793    25255.961693   7843.970620
```

Sort

```
In [83]: df = df.sort_values(by='GDP percap', ascending=False)

In [84]: df
Out[84]:
               population      total GDP   GDP percap
country
United States   282171957  9898700.000000  35080.381854
Australia        19053186   541804.652100  28436.433261
Israel            6114570   129253.894230  21138.672749
Argentina        37335653   295072.218690   7903.229085
Uruguay           3219793    25255.961693   7843.970620
South Africa     45064098   227242.369490   5042.647686
India          1006300297  1728144.374800   1717.324719
Malawi           11801505     5026.221784    425.896679
```

Pandas plot

```
In [76]: df['GDP percap'].plot(kind='bar')
Out[76]: <matplotlib.axes.AxesSubplot at 0x2f22ed0>
```



DataFrame

- DF from dict

```
data = {'state': ['Ohio', 'Ohio', 'Ohio', 'Nevada', 'Nevada'],
        'year': [2000, 2001, 2002, 2001, 2002],
        'pop': [1.5, 1.7, 3.6, 2.4, 2.9]}
frame = DataFrame(data)
```

  - Specifing a sequence & index

```
In [40]: frame2 = DataFrame(data, columns=['year', 'state', 'pop', 'debt'],
   ....:                    index=['one', 'two', 'three', 'four', 'five'])

In [41]: frame2
Out[41]:
       year   state  pop  debt
one    2000    Ohio  1.5   NaN
two    2001    Ohio  1.7   NaN
three  2002    Ohio  3.6   NaN
four   2001  Nevada  2.4   NaN
five   2002  Nevada  2.9   NaN
```

Time-Series Data

```
In [6]: dates = pd.date_range('20130101', periods=6)

In [7]: dates
Out[7]:
DatetimeIndex(['2013-01-01', '2013-01-02', '2013-01-03', '2013-01-04',
               '2013-01-05', '2013-01-06'],
              dtype='datetime64[ns]', freq='D')

In [8]: df = pd.DataFrame(np.random.randn(6,4), index=dates, columns=list('ABCD'))

In [9]: df
Out[9]:
                   A         B         C         D
2013-01-01  0.469112 -0.282863 -1.509059 -1.135632
2013-01-02  1.212112 -0.173215  0.119209 -1.044236
2013-01-03 -0.861849 -2.104569 -0.494929  1.071804
2013-01-04  0.721555 -0.706771 -1.039575  0.271860
2013-01-05 -0.424972  0.567020  0.276232 -1.087401
2013-01-06 -0.673690  0.113648 -1.478427  0.524988
```

Viewing Data

```
In [14]: df.head()
Out[14]:
                   A         B         C         D
2013-01-01  0.469112 -0.282863 -1.509059 -1.135632
2013-01-02  1.212112 -0.173215  0.119209 -1.044236
2013-01-03 -0.861849 -2.104569 -0.494929  1.071804
2013-01-04  0.721555 -0.706771 -1.039575  0.271860
2013-01-05 -0.424972  0.567020  0.276232 -1.087401

In [15]: df.tail(3)
Out[15]:
                   A         B         C         D
2013-01-04  0.721555 -0.706771 -1.039575  0.271860
2013-01-05 -0.424972  0.567020  0.276232 -1.087401
2013-01-06 -0.673690  0.113648 -1.478427  0.524988
```

```
In [16]: df.index
Out[16]:
DatetimeIndex(['2013-01-01', '2013-01-02', '2013-01-03', '2013-01-04'
               '2013-01-05', '2013-01-06'],
              dtype='datetime64[ns]', freq='D')

In [17]: df.columns
Out[17]: Index(['A', 'B', 'C', 'D'], dtype='object')
```

Selection by Label : loc

```
In [26]: df.loc[dates[0]]
Out[26]:
A    0.469112
B   -0.282863
C   -1.509059
D   -1.135632
Name: 2013-01-01 00:00:00, dtype: float64
```

```
In [27]: df.loc[:,['A','B']]
Out[27]:
                   A         B
2013-01-01  0.469112 -0.282863
2013-01-02  1.212112 -0.173215
2013-01-03 -0.861849 -2.104569
2013-01-04  0.721555 -0.706771
2013-01-05 -0.424972  0.567020
2013-01-06 -0.673690  0.113648
```

```
In [28]: df.loc['20130102':'20130104',['A','B']]
Out[28]:
                   A         B
2013-01-02  1.212112 -0.173215
2013-01-03 -0.861849 -2.104569
2013-01-04  0.721555 -0.706771
```

Selection by Position : iloc

```
In [32]: df.iloc[3]
Out[32]:
A    0.721555
B   -0.706771
C   -1.039575
D    0.271860
Name: 2013-01-04 00:00:00, dtype: float64
```

```
In [33]: df.iloc[3:5,0:2]
Out[33]:
                   A         B
2013-01-04  0.721555 -0.706771
2013-01-05 -0.424972  0.567020
```

```
In [34]: df.iloc[[1,2,4],[0,2]]
Out[34]:
                   A         C
2013-01-02  1.212112  0.119209
2013-01-03 -0.861849 -0.494929
2013-01-05 -0.424972  0.276232
```

```
In [37]: df.iloc[1,1]
Out[37]: -0.17321464905330858
```

Boolean-indexing

```
In [39]: df[df.A > 0]
Out[39]:
                   A         B         C         D
2013-01-01  0.469112 -0.282863 -1.509059 -1.135632
2013-01-02  1.212112 -0.173215  0.119209 -1.044236
2013-01-04  0.721555 -0.706771 -1.039575  0.271860
```

```
In [40]: df[df > 0]
Out[40]:
                   A         B         C         D
2013-01-01  0.469112       NaN       NaN       NaN
2013-01-02  1.212112       NaN  0.119209       NaN
2013-01-03       NaN       NaN       NaN  1.071804
2013-01-04  0.721555       NaN       NaN  0.271860
2013-01-05       NaN  0.567020  0.276232       NaN
2013-01-06       NaN  0.113648       NaN  0.524988
```

```
                   A         B         C         D      E
2013-01-01  0.469112 -0.282863 -1.509059 -1.135632    one
2013-01-02  1.212112 -0.173215  0.119209 -1.044236    one
2013-01-03 -0.861849 -2.104569 -0.494929  1.071804    two
2013-01-04  0.721555 -0.706771 -1.039575  0.271860  three
2013-01-05 -0.424972  0.567020  0.276232 -1.087401   four
2013-01-06 -0.673690  0.113648 -1.478427  0.524988  three

In [44]: df2[df2['E'].isin(['two','four'])]
Out[44]:
                   A         B         C         D     E
2013-01-03 -0.861849 -2.104569 -0.494929  1.071804   two
2013-01-05 -0.424972  0.567020  0.276232 -1.087401  four
```

Function application

```
In [158]: frame = DataFrame(np.random.randn(4, 3), columns=list('bde'),
   .....:                   index=['Utah', 'Ohio', 'Texas', 'Oregon'])
```

```
In [159]: frame
Out[159]:
               b         d         e
Utah   -0.204708  0.478943 -0.519439
Ohio   -0.555730  1.965781  1.393406
Texas   0.092908  0.281746  0.769023
Oregon  1.246435  1.007189 -1.296221
```

```
In [160]: np.abs(frame)
Out[160]:
               b         d         e
Utah    0.204708  0.478943  0.519439
Ohio    0.555730  1.965781  1.393406
Texas   0.092908  0.281746  0.769023
Oregon  1.246435  1.007189  1.296221
```

```
In [161]: f = lambda x: x.max() - x.min()
```

```
In [162]: frame.apply(f)
Out[162]:
b    1.802165
d    1.684034
e    2.689627
```

```
In [163]: frame.apply(f, axis=1)
Out[163]:
Utah      0.998382
Ohio      2.521511
Texas     0.676115
Oregon    2.542656
```

```
In [166]: format = lambda x: '%.2f' % x

In [167]: frame.applymap(format)
Out[167]:
            b     d      e
Utah    -0.20  0.48  -0.52
Ohio    -0.56  1.97   1.39
Texas    0.09  0.28   0.77
Oregon   1.25  1.01  -1.30
```

Descriptive & Summary

Method	Description
count	Number of non-NA values
describe	Compute set of summary statistics for Series or each DataFrame column
min, max	Compute minimum and maximum values
argmin, argmax	Compute index locations (integers) at which minimum or maximum value obtained, respectively
idxmin, idxmax	Compute index values at which minimum or maximum value obtained, respectively
quantile	Compute sample quantile ranging from 0 to 1
sum	Sum of values
mean	Mean of values
median	Arithmetic median (50% quantile) of values
mad	Mean absolute deviation from mean value
var	Sample variance of values
std	Sample standard deviation of values
skew	Sample skewness (3rd moment) of values
kurt	Sample kurtosis (4th moment) of values
cumsum	Cumulative sum of values
cummin, cummax	Cumulative minimum or maximum of values, respectively
cumprod	Cumulative product of values
diff	Compute 1st arithmetic difference (useful for time series)
pct_change	Compute percent changes

Correlation & Covariance

```
In [209]: returns = price.pct_change()

In [210]: returns.tail()

Out[210]:
                AAPL      GOOG       IBM      MSFT
Date
2009-12-24  0.034339  0.011117  0.004420  0.002747
2009-12-28  0.012294  0.007098  0.013282  0.005479
2009-12-29 -0.011861 -0.005571 -0.003474  0.006812
2009-12-30  0.012147  0.005376  0.005468 -0.013532
2009-12-31 -0.004300 -0.004416 -0.012609 -0.015432
```

```
In [213]: returns.corr()
Out[213]:
          AAPL      GOOG       IBM      MSFT
AAPL  1.000000  0.470660  0.410648  0.424550
GOOG  0.470660  1.000000  0.390692  0.443334
IBM   0.410648  0.390692  1.000000  0.496093
MSFT  0.424550  0.443334  0.496093  1.000000

In [214]: returns.cov()
Out[214]:
          AAPL      GOOG       IBM      MSFT
AAPL  0.001028  0.000303  0.000252  0.000309
GOOG  0.000303  0.000580  0.000142  0.000205
IBM   0.000252  0.000142  0.000367  0.000216
MSFT  0.000309  0.000205  0.000216  0.000516

In [215]: returns.corrwith(returns.IBM)
Out[215]:
AAPL    0.410648
GOOG    0.390692
IBM     1.000000
MSFT    0.496093
```

Handling Missing Data

- isnull() / notnull()

```
In [229]: string_data = Series(['aardvark', 'artichoke', np.nan, 'avocado'])

In [230]: string_data
Out[230]:
0     aardvark
1    artichoke
2          NaN
3      avocado
```

```
In [231]: string_data.isnull()
Out[231]:
0    False
1    False
2     True
3    False
```

```
In [232]: string_data[0] = None

In [233]: string_data.isnull()
Out[233]:
0     True
1    False
2     True
3    False
```

Dropping Missing Data

```
In [238]: data = DataFrame([[1., 6.5, 3.], [1., NA, NA],
   .....:                   [NA, NA, NA], [NA, 6.5, 3.]])

In [239]: cleaned = data.dropna()

In [240]: data
Out[240]:
     0    1    2
0    1  6.5    3
1    1  NaN  NaN
2  NaN  NaN  NaN
3  NaN  6.5    3

In [241]: cleaned
Out[241]:
   0    1  2
0  1  6.5  3

In [242]: data.dropna(how='all')
Out[242]:
     0    1    2
0    1  6.5    3
1    1  NaN  NaN
3  NaN  6.5    3

In [243]: data[4] = NA

In [244]: data
Out[244]:
     0    1    2    4
0    1  6.5    3  NaN
1    1  NaN  NaN  NaN
2  NaN  NaN  NaN  NaN
3  NaN  6.5    3  NaN

In [245]: data.dropna(axis=1, how='all')
Out[245]:
     0    1    2
0    1  6.5    3
1    1  NaN  NaN
2  NaN  NaN  NaN
3  NaN  6.5    3
```

Filling in Missing Data

```
In [250]: df.fillna(0)
Out[250]:
          0         1         2
0 -0.577087  0.000000  0.000000
1  0.523772  0.000000  0.000000
2 -0.713544  0.000000  0.000000
3 -1.860761  0.000000  0.560145
4 -1.265934  0.000000 -1.063512
5  0.332883 -2.359419 -0.199543
6 -1.541996 -0.970736 -1.307030
```

```
In [251]: df.fillna({1: 0.5, 3: -1})
Out[251]:
          0         1         2
0 -0.577087  0.500000       NaN
1  0.523772  0.500000       NaN
2 -0.713544  0.500000       NaN
3 -1.860761  0.500000  0.560145
4 -1.265934  0.500000 -1.063512
5  0.332883 -2.359419 -0.199543
6 -1.541996 -0.970736 -1.307030
```

```
In [256]: df
Out[256]:
          0         1         2
0  0.286350  0.377984 -0.753887
1  0.331286  1.349742  0.069877
2  0.246674       NaN  1.004812
3  1.327195       NaN -1.549106
4  0.022185       NaN       NaN
5  0.862580       NaN       NaN
```

```
In [257]: df.fillna(method='ffill')
Out[257]:
          0         1         2
0  0.286350  0.377984 -0.753887
1  0.331286  1.349742  0.069877
2  0.246674  1.349742  1.004812
3  1.327195  1.349742 -1.549106
4  0.022185  1.349742 -1.549106
5  0.862580  1.349742 -1.549106
```

```
In [258]: df.fillna(method='ffill', limit=2)
Out[258]:
          0         1         2
0  0.286350  0.377984 -0.753887
1  0.331286  1.349742  0.069877
2  0.246674  1.349742  1.004812
3  1.327195  1.349742 -1.549106
4  0.022185       NaN -1.549106
5  0.862580       NaN -1.549106
```

Filling in Missing Data

```
In [259]: data = Series([1., NA, 3.5, NA, 7])

In [260]: data.fillna(data.mean())
Out[260]:
0    1.000000
1    3.833333
2    3.500000
3    3.833333
4    7.000000
```

Argument	Description
`value`	Scalar value or dict-like object to use to fill missing values
`method`	Interpolation, by default `'ffill'` if function called with no other arguments
`axis`	Axis to fill on, default `axis=0`
`inplace`	Modify the calling object without producing a copy
`limit`	For forward and backward filling, maximum number of consecutive periods to fill

Merge

- concat
- merge
- append

https://pandas.pydata.org/pandas-docs/stable/merging.html

Grouping

- splitting
- applying
- combining

https://pandas.pydata.org/pandas-docs/stable/groupby.html#

Shifting / lagging

```
In [183]: ts = ts[:5]

In [184]: ts.shift(1)
Out[184]:
2011-01-31          NaN
2011-02-28   -1.281247
2011-03-31   -0.727707
2011-04-29   -0.121306
2011-05-31   -0.097883
Freq: BM, dtype: float64
```

Panel Data

```
In [124]: import pandas_datareader.data as pdd

In [125]: data = pdd.DataReader(["GOOG","MSFT","FB"],"yahoo")

In [126]: data
Out[126]:
<class 'pandas.core.panel.Panel'>
Dimensions: 6 (items) x 1553 (major_axis) x 3 (minor_axis)
Items axis: Open to Adj Close
Major_axis axis: 2010-01-04 00:00:00 to 2016-03-04 00:00:00
Minor_axis axis: FB to MSFT
```

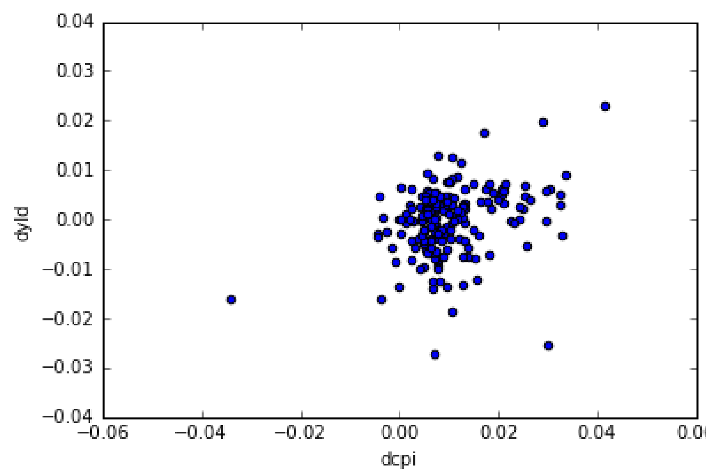
```
In [134]: d = data["Close"]

In [135]: d.tail()
Out[135]:
                    FB        GOOG       MSFT
Date
2016-02-29  106.919998  697.770020  50.880001
2016-03-01  109.820000  718.809998  52.580002
2016-03-02  109.949997  718.849976  52.950001
2016-03-03  109.580002  712.419983  52.349998
2016-03-04  108.389999  710.890015  52.029999
```

```
In [136]: d = data["Close",:3]

In [137]: d
Out[137]:
             FB        GOOG       MSFT
Date
2010-01-04 NaN  626.751061  30.950001
2010-01-05 NaN  623.991055  30.959999
2010-01-06 NaN  608.261023  30.770000

In [138]: d = data["Close",:3,"MSFT"]

In [139]: d
Out[139]:
Date
2010-01-04    30.950001
2010-01-05    30.959999
2010-01-06    30.770000
Name: MSFT, dtype: float64
```

OLS

```
In [43]: import datetime as dt
    ...: import pandas as pd
    ...:
    ...: s = dt.datetime(1970,1,1)
    ...: e = dt.datetime(2016,1,1)
    ...: data = pdd.DataReader(["DGS10","CPIAUCSL"],"fred",start=s,end=e)
    ...: d = data.resample("q", how="last", fill_method='ffill')
    ...: d['dyld'] = d['DGS10'].diff() / 100.0
    ...: d['dcpi'] = d['CPIAUCSL'].pct_change()
    ...: d.plot(kind='scatter',x='dcpi',y='dyld')
    ...: res = pd.ols(x=d['dcpi'],y=d['dyld'])
    ...: print(res)
```

```
-------------------------Summary of Regression Analysis-------------------------

Formula: Y ~ <x> + <intercept>

Number of Observations:         184
Number of Degrees of Freedom:   2

R-squared:         0.1027
Adj R-squared:     0.0977

Rmse:              0.0065

F-stat (1, 182):    20.8221, p-value:     0.0000

Degrees of Freedom: model 1, resid 182
```




```
-----------------------Summary of Estimated Coefficients------------------------
      Variable       Coef    Std Err     t-stat    p-value    CI 2.5%   CI 97.5%
--------------------------------------------------------------------------------
             x     0.2514     0.0551       4.56     0.0000     0.1434     0.3593
     intercept    -0.0028     0.0007      -3.79     0.0002    -0.0042    -0.0013
---------------------------------End of Summary---------------------------------
```

OLS results

```
In [49]: res.beta
Out[49]:
x            0.251371
intercept   -0.002780
dtype: float64

In [50]: type(res.beta)
Out[50]: pandas.core.series.Series

In [51]: res.beta['x']
Out[51]: 0.25137137421697525

In [52]: res.r2_adj
Out[52]: 0.097731631537190555

In [53]: res.x
Out[53]:
                   x  intercept
DATE
1970-06-30  0.013055          1
1970-09-30  0.010309          1
1970-12-31  0.015306          1
1971-03-31  0.005025          1
1971-06-30  0.012500          1
1971-09-30  0.007407          1
```

```
In [65]: res.summary_as_matrix
Out[65]:
                x  intercept
beta     0.251371  -0.002780
p-value  0.000009   0.000204
std err  0.055088   0.000733
t-stat   4.563128  -3.791296

In [66]: type(res.summary_as_matrix)
Out[66]: pandas.core.frame.DataFrame
```