Importing pandas

Getting started and checking your pandas setup

Difficulty: *easy*

1. Import pandas under the alias pd.

```
import pandas as pd
```

2. Print the version of pandas that has been imported.

```
pd.__version__
```

3. Print out all the version information of the libraries that are required by the pandas library.

```
pd.show_versions()
```

DataFrame basics

A few of the fundamental routines for selecting, sorting, adding and aggregating data in DataFrames

Difficulty: *easy*

Note: remember to import numpy using:

import numpy **as** np

Consider the following Python dictionary data and Python list labels:

data **=** {'animal': ['cat', 'cat', 'snake', 'dog', 'dog', 'cat', 'snake', 'cat', 'dog', 'dog'],
'age': [2.5, 3, 0.5, np.nan, 5, 2, 4.5, np.nan, 7, 3],
'visits': [1, 3, 2, 3, 2, 3, 1, 1, 2, 1],
'priority': ['yes', 'yes', 'no', 'yes', 'no', 'no', 'no', 'yes', 'no', 'no']}

labels **=** ['a', 'b', 'c', 'd', 'e', 'f', 'g', 'h', 'i', 'j']

(This is just some meaningless data I made up with the theme of animals and trips to a vet.)

4. Create a DataFrame df from this dictionary data which has the index labels.

```
import numpy as np

data = {'animal': ['cat', 'cat', 'snake', 'dog', 'dog', 'cat', 'snake',
'cat', 'dog', 'dog'],
        'age': [2.5, 3, 0.5, np.nan, 5, 2, 4.5, np.nan, 7, 3],
        'visits': [1, 3, 2, 3, 2, 3, 1, 1, 2, 1],
        'priority': ['yes', 'yes', 'no', 'yes', 'no', 'no', 'no', 'yes',
'no', 'no']}

labels = ['a', 'b', 'c', 'd', 'e', 'f', 'g', 'h', 'i', 'j']

df = pd.DataFrame(data, index=labels)
```

5. Display a summary of the basic information about this DataFrame and its data (*hint: there is a single method that can be called on the DataFrame*).

```
df.info()
```

6. Return the first 3 rows of the DataFrame df.

```
df.head(3)
```

7. Select just the 'animal' and 'age' columns from the DataFrame df.

```
df[['animal', 'age']]
```

8. Select the data in rows [3, 4, 8] *and* in columns ['animal', 'age'].

```
df.loc[df.index[[3, 4, 8]], ['animal', 'age']]
```

9. Select only the rows where the number of visits is greater than 3.

```
df[df['visits'] > 3]
```

10. Select the rows where the age is missing, i.e. it is NaN.

```
df[df['age'].isnull()]
```

11. Select the rows where the animal is a cat *and* the age is less than 3.

```
df[(df['animal'] == 'cat') & (df['age'] < 3)]
```

12. Select the rows the age is between 2 and 4 (inclusive).

```
df[df['age'].between(2, 4)]
```

13. Change the age in row 'f' to 1.5.

```
df.loc['f', 'age'] = 1.5
```

14. Calculate the sum of all visits in df (i.e. the total number of visits).

```
df['visits'].sum()
```

15. Calculate the mean age for each different animal in df.

```
df.groupby('animal')['age'].mean()
```

16. Append a new row 'k' to df with your choice of values for each column. Then delete that row to return the original DataFrame.

```
df.loc['k'] = [5.5, 'dog', 'no', 2]

df = df.drop('k')
```

17. Count the number of each type of animal in df.

```
df['animal'].value_counts()
```

18. Sort df first by the values in the 'age' in *decending* order, then by the value in the 'visits' column in *ascending* order (so row i should be first, and row d should be last).

```
df.sort_values(by=['age', 'visits'], ascending=[False, True])
```

19. The 'priority' column contains the values 'yes' and 'no'. Replace this column with a column of boolean values: 'yes' should be True and 'no' should be False.

```
df['priority'] = df['priority'].map({'yes': True, 'no': False})
```

20. In the 'animal' column, change the 'snake' entries to 'python'.

```
df['animal'] = df['animal'].replace('snake', 'python')
```

21. For each animal type and each number of visits, find the mean age. In other words, each row is an animal, each column is a number of visits and the values are the mean ages (*hint: use a pivot table*).

```
df.pivot_table(index='animal', columns='visits', values='age',
aggfunc='mean')
```

DataFrames: beyond the basics

Slightly trickier: you may need to combine two or more methods to get the right answer

Difficulty: *medium*

The previous section was tour through some basic but essential DataFrame operations. Below are some ways that you might need to cut your data, but for which there is no single "out of the box" method.

22. You have a DataFrame df with a column 'A' of integers. For example:

df = pd.DataFrame({'A': [1, 2, 2, 3, 4, 5, 5, 5, 6, 7, 7]})

How do you filter out rows which contain the same integer as the row immediately above?

You should be left with a column containing the following values:

1, 2, 3, 4, 5, 6, 7

```
df = pd.DataFrame({'A': [1, 2, 2, 3, 4, 5, 5, 5, 6, 7, 7]})

df.loc[df['A'].shift() != df['A']]

df.drop_duplicates(subset='A')
```

23. Given a DataFrame of random numeric values:

df = pd.DataFrame(np.random.random(size=(5, 3))) *# this is a 5x3 DataFrame of float values*

how do you subtract the row mean from each element in the row?

```
df = pd.DataFrame(np.random.random(size=(5, 3)))

df.sub(df.mean(axis=1), axis=0)
```

24. Suppose you have DataFrame with 10 columns of real numbers, for example:

df = pd.DataFrame(np.random.random(size=(5, 10)), columns=list('abcdefghij'))

Which column of numbers has the smallest sum? Return that column's label.

```
df = pd.DataFrame(np.random.random(size=(5, 10)),
columns=list('abcdefghij'))

df.sum().idxmin()
```

25. How do you count how many unique rows a DataFrame has (i.e. ignore all rows that are duplicates)?

```
len(df.drop_duplicates(keep=False))
```

The next three puzzles are slightly harder.

26. In the cell below, you have a DataFrame df that consists of 10 columns of floating-point numbers. Exactly 5 entries in each row are NaN values.

For each row of the DataFrame, find the *column* which contains the *third* NaN value.

You should return a Series of column labels: e, c, d, h, d

```
nan = np.nan

data = [[0.04,  nan,  nan, 0.25,  nan, 0.43, 0.71, 0.51,  nan,  nan],
        [ nan,  nan,  nan, 0.04, 0.76,  nan,  nan, 0.67, 0.76, 0.16],
        [ nan,  nan, 0.5 ,  nan, 0.31, 0.4 ,  nan,  nan, 0.24, 0.01],
        [0.49,  nan,  nan, 0.62, 0.73, 0.26, 0.85,  nan,  nan,  nan],
        [ nan,  nan, 0.41,  nan, 0.05,  nan, 0.61,  nan, 0.48, 0.68]]

columns = list('abcdefghij')

df = pd.DataFrame(data, columns=columns)


(df.isnull().cumsum(axis=1) == 3).idxmax(axis=1)
```

27. A DataFrame has a column of groups 'grps' and and column of integer values 'vals':

df = pd.DataFrame({'grps': list('aaabbcaabcccbbc'),
'vals': [12,345,3,1,45,14,4,52,54,23,235,21,57,3,87]})

For each *group*, find the sum of the three greatest values. You should end up with the answer as follows:

grps

a 409

b 156

c 345

```
df = pd.DataFrame({'grps': list('aaabbcaabcccbbc'),
                   'vals': [12,345,3,1,45,14,4,52,54,23,235,21,57,3,87]})

df.groupby('grps')['vals'].nlargest(3).sum(level=0)
```

28. The DataFrame df constructed below has two integer columns 'A' and 'B'. The values in 'A' are between 1 and 100 (inclusive).

For each group of 10 consecutive integers in 'A' (i.e. (0, 10], (10, 20], ...), calculate the sum of the corresponding values in column 'B'.

The answer should be a Series as follows:

A

(0, 10] 635

(10, 20] 360

(20, 30] 315

(30, 40] 306

(40, 50] 750

(50, 60]	284
(60, 70]	424
(70, 80]	526
(80, 90]	835
(90, 100]	852

```
df = pd.DataFrame(np.random.RandomState(8765).randint(1, 101, size=(100,
2)), columns = ["A", "B"])

df.groupby(pd.cut(df['A'], np.arange(0, 101, 10)))['B'].sum()
```

DataFrames: harder problems

These might require a bit of thinking outside the box...

...but all are solvable using just the usual pandas/NumPy methods (and so avoid using explicit for loops).

Difficulty: *hard*

29. Consider a DataFrame df where there is an integer column 'X':

df = pd.DataFrame({'X': [7, 2, 0, 3, 4, 2, 5, 0, 3, 4]})

For each value, count the difference back to the previous zero (or the start of the Series, whichever is closer). These values should therefore be

    [1, 2, 0, 1, 2, 3, 4, 0, 1, 2]

Make this a new column 'Y'.

```
df = pd.DataFrame({'X': [7, 2, 0, 3, 4, 2, 5, 0, 3, 4]})

izero = np.r_[-1, (df == 0).values.nonzero()[0]]  # indices of zeros
idx = np.arange(len(df))
y = df['X'] != 0
df['Y'] = idx - izero[np.searchsorted(izero - 1, idx) - 1]

# http://stackoverflow.com/questions/30730981/how-to-count-distance-to-the-
previous-zero-in-pandas-series/
# credit: Behzad Nouri
```

Here's an alternative approach based on a [cookbook recipe]():

```
df = pd.DataFrame({'X': [7, 2, 0, 3, 4, 2, 5, 0, 3, 4]})

x = (df['X'] != 0).cumsum()
y = x != x.shift()
df['Y'] = y.groupby((y != y.shift()).cumsum()).cumsum()
```

30. Consider the DataFrame constructed below which contains rows and columns of numerical data.

Create a list of the column-row index locations of the 3 largest values in this DataFrame. In this case, the answer should be:

[(5, 7), (6, 4), (2, 5)]

```
df = pd.DataFrame(np.random.RandomState(30).randint(1, 101, size=(8, 8)))

df.unstack().sort_values()[-3:].index.tolist()

# http://stackoverflow.com/questions/14941261/index-and-column-for-the-max-value-in-pandas-dataframe/
# credit: DSM
```

31. You are given the DataFrame below with a column of group IDs, 'grps', and a column of corresponding integer values, 'vals'.

```
df = pd.DataFrame({"vals": np.random.RandomState(31).randint(-30, 30, size=15),
             "grps": np.random.RandomState(31).choice(["A", "B"], 15)})
```

Create a new column 'patched_values' which contains the same values as the 'vals' any negative values in 'vals' with the group mean:

	vals	grps	patched_vals
0	-12	A	13.6
1	-7	B	28.0
2	-14	A	13.6
3	4	A	4.0
4	-7	A	13.6
5	28	B	28.0
6	-2	A	13.6
7	-1	A	13.6
8	8	A	8.0
9	-2	B	28.0
10	28	A	28.0
11	12	A	12.0
12	16	A	16.0
13	-24	A	13.6

14 -12 A 13.6

```
df = pd.DataFrame({"vals": np.random.RandomState(31).randint(-30, 30, size=15),
                   "grps": np.random.RandomState(31).choice(["A", "B"], 15)})

def replace(group):
    mask = group<0
    group[mask] = group[~mask].mean()
    return group

df.groupby(['grps'])['vals'].transform(replace)

# http://stackoverflow.com/questions/14760757/replacing-values-with-groupby-means/
# credit: unutbu
```

32. Implement a rolling mean over groups with window size 3, which ignores NaN value. For example consider the following DataFrame:

```
>>> df = pd.DataFrame({'group': list('aabbabbbabab'),
          'value': [1, 2, 3, np.nan, 2, 3, np.nan, 1, 7, 3, np.nan, 8]})
>>> df
  group  value
0     a    1.0
1     a    2.0
2     b    3.0
3     b    NaN
4     a    2.0
5     b    3.0
6     b    NaN
7     b    1.0
8     a    7.0
9     b    3.0
10    a    NaN
11    b    8.0
```

The goal is to compute the Series:

```
0    1.000000

1    1.500000

2    3.000000

3    3.000000

4    1.666667

5    3.000000

6    3.000000

7    2.000000
```

8   3.666667

9   2.000000

10   4.500000

11   4.000000

E.g. the first window of size three for group 'b' has values 3.0, NaN and 3.0 and occurs at row index 5. Instead of being NaN the value in the new column at this row index should be 3.0 (just the two non-NaN values are used to compute the mean (3+3)/2)

```
df = pd.DataFrame({'group': list('aabbabbbabab'),
                   'value': [1, 2, 3, np.nan, 2, 3, np.nan, 1, 7, 3,
np.nan, 8]})

g1 = df.groupby(['group'])['value']
g2 = df.fillna(0).groupby(['group'])['value']

s = g2.rolling(3, min_periods=1).sum() / g1.rolling(3,
min_periods=1).count() # compute means

s.reset_index(level=0, drop=True).sort_index()
```

Series and DatetimeIndex

Exercises for creating and manipulating Series with datetime data

Difficulty: *easy/medium*

pandas is fantastic for working with dates and times. These puzzles explore some of this functionality.

33. Create a DatetimeIndex that contains each business day of 2015 and use it to index a Series of random numbers. Let's call this Series s.

```
dti = pd.date_range(start='2015-01-01', end='2015-12-31', freq='B')
s = pd.Series(np.random.rand(len(dti)), index=dti)
s
```

34. Find the sum of the values in s for every Wednesday.

```
s[s.index.weekday == 2].sum()
```

35. For each calendar month in s, find the mean of values.

```
s.resample('M').mean()
```

36. For each group of four consecutive calendar months in s, find the date on which the highest value occurred.

```
s.groupby(pd.Grouper(freq='4M')).idxmax()
```

37. Create a DateTimeIndex consisting of the third Thursday in each month for the years 2015 and 2016.

```
pd.date_range('2015-01-01', '2016-12-31', freq='WOM-3THU')
```

Cleaning Data

Making a DataFrame easier to work with

Difficulty: *easy/medium*

It happens all the time: someone gives you data containing malformed strings, Python, lists and missing data. How do you tidy it up so you can get on with the analysis?

Take this monstrosity as the DataFrame to use in the following puzzles:

```
df = pd.DataFrame({'From_To': ['LoNDon_paris', 'MAdrid_miLAN', 'londON_StockhOlm',
                    'Budapest_PaRis', 'Brussels_londOn'],
          'FlightNumber': [10045, np.nan, 10065, np.nan, 10085],
          'RecentDelays': [[23, 47], [], [24, 43, 87], [13], [67, 32]],
            'Airline': ['KLM(!)', '<Air France> (12)', '(British Airways. )',
                    '12. Air France', '"Swiss Air"']})
```

Formatted, it looks like this:

	From_To	FlightNumber	RecentDelays	Airline
0	LoNDon_paris	10045.0	[23, 47]	KLM(!)
1	MAdrid_miLAN	NaN	[]	<Air France> (12)
2	londON_StockhOlm	10065.0	[24, 43, 87]	(British Airways.)
3	Budapest_PaRis	NaN	[13]	12. Air France
4	Brussels_londOn	10085.0	[67, 32]	"Swiss Air"

(It's some flight data I made up; it's not meant to be accurate in any way.)

38. Some values in the the **FlightNumber** column are missing (they are NaN). These numbers are meant to increase by 10 with each row so 10055 and 10075 need to be put in place. Modify df to fill in these missing numbers and make the column an integer column (instead of a float column).

```
df = pd.DataFrame({'From_To': ['LoNDon_paris', 'MAdrid_miLAN', 
'londON_StockhOlm',
                               'Budapest_PaRis', 'Brussels_londOn'],
              'FlightNumber': [10045, np.nan, 10065, np.nan, 10085],
              'RecentDelays': [[23, 47], [], [24, 43, 87], [13], [67, 32]],
                   'Airline': ['KLM(!)', '<Air France> (12)', '(British 
Airways. )',
                               '12. Air France', '"Swiss Air"']})

df['FlightNumber'] = df['FlightNumber'].interpolate().astype(int)
df
```

39. The **From_To** column would be better as two separate columns! Split each string on the underscore delimiter _ to give a new temporary DataFrame called 'temp' with the correct values. Assign the correct column names 'From' and 'To' to this temporary DataFrame.

```
temp = df.From_To.str.split('_', expand=True)
```

```
temp.columns = ['From', 'To']
temp
```

40. Notice how the capitalisation of the city names is all mixed up in this temporary DataFrame 'temp'. Standardise the strings so that only the first letter is uppercase (e.g. "londON" should become "London".)

```
temp['From'] = temp['From'].str.capitalize()
temp['To'] = temp['To'].str.capitalize()
temp
```

41. Delete the From_To column from **41.** Delete the **From_To** column from df and attach the temporary DataFrame 'temp' from the previous questions.df and attach the temporary DataFrame from the previous questions.

```
df = df.drop('From_To', axis=1)
df = df.join(temp)
df
```

42. In the **Airline** column, you can see some extra puctuation and symbols have appeared around the airline names. Pull out just the airline name. E.g. '(British Airways.)' should become 'British Airways'.

```
df['Airline'] = df['Airline'].str.extract('([a-zA-Z\s]+)',
expand=False).str.strip()
# note: using .strip() gets rid of any leading/trailing spaces
df
```

43. In the **RecentDelays** column, the values have been entered into the DataFrame as a list. We would like each first value in its own column, each second value in its own column, and so on. If there isn't an Nth value, the value should be NaN.

Expand the Series of lists into a new DataFrame named 'delays', rename the columns 'delay_1', 'delay_2', etc. and replace the unwanted RecentDelays column in df with 'delays'.

```
# there are several ways to do this, but the following approach is possibly
the simplest

delays = df['RecentDelays'].apply(pd.Series)

delays.columns = ['delay_{}'.format(n) for n in range(1,
len(delays.columns)+1)]

df = df.drop('RecentDelays', axis=1).join(delays)

df
```

The DataFrame should look much better now:

	FlightNumber	Airline	From	To	delay_1	delay_2	delay_3
0	10045	KLM	London	Paris	23.0	47.0	NaN
1	10055	Air France	Madrid	Milan	NaN	NaN	NaN
2	10065	British Airways	London	Stockholm	24.0	43.0	87.0
3	10075	Air France	Budapest	Paris	13.0	NaN	NaN

4	10085	Swiss Air	Brussels	London	67.0	32.0	NaN

Using MultiIndexes

Go beyond flat DataFrames with additional index levels

Difficulty: *medium*

Previous exercises have seen us analysing data from DataFrames equipped with a single index level. However, pandas also gives you the possibilty of indexing your data using *multiple* levels. This is very much like adding new dimensions to a Series or a DataFrame. For example, a Series is 1D, but by using a MultiIndex with 2 levels we gain of much the same functionality as a 2D DataFrame.

The set of puzzles below explores how you might use multiple index levels to enhance data analysis.

To warm up, we'll look make a Series with two index levels.

44. Given the lists letters = ['A', 'B', 'C'] and numbers = list(range(10)), construct a MultiIndex object from the product of the two lists. Use it to index a Series of random numbers. Call this Series s.

```
letters = ['A', 'B', 'C']
numbers = list(range(10))

mi = pd.MultiIndex.from_product([letters, numbers])
s = pd.Series(np.random.rand(30), index=mi)
s
```

45. Check the index of s is lexicographically sorted (this is a necessary proprty for indexing to work correctly with a MultiIndex).

```
s.index.is_lexsorted()

# or more verbosely...
s.index.lexsort_depth == s.index.nlevels
```

46. Select the labels 1, 3 and 6 from the second level of the MultiIndexed Series.

```
s.loc[:, [1, 3, 6]]
```

47. Slice the Series s; slice up to label 'B' for the first level and from label 5 onwards for the second level.

```
s.loc[pd.IndexSlice[:'B', 5:]]

# or equivalently without IndexSlice...
s.loc[slice(None, 'B'), slice(5, None)]
```

48. Sum the values in s for each label in the first level (you should have Series giving you a total for labels A, B and C).

```
s.sum(level=0)
```

49. Suppose that sum() (and other methods) did not accept a level keyword argument. How else could you perform the equivalent of s.sum(level=1)?

```
# One way is to use .unstack()...
# This method should convince you that s is essentially just a regular DataFrame in disguise!
s.unstack().sum(axis=0)
```

50. Exchange the levels of the MultiIndex so we have an index of the form (letters, numbers). Is this new Series properly lexsorted? If not, sort it.

```
new_s = s.swaplevel(0, 1)

if not new_s.index.is_lexsorted():
    new_s = new_s.sort_index()

new_s
```

Minesweeper

Generate the numbers for safe squares in a Minesweeper grid

Difficulty: *medium* to *hard*

If you've ever used an older version of Windows, there's a good chance you've played with Minesweeper:

- https://en.wikipedia.org/wiki/Minesweeper_(video_game)

If you're not familiar with the game, imagine a grid of squares: some of these squares conceal a mine. If you click on a mine, you lose instantly. If you click on a safe square, you reveal a number telling you how many mines are found in the squares that are immediately adjacent. The aim of the game is to uncover all squares in the grid that do not contain a mine.

In this section, we'll make a DataFrame that contains the necessary data for a game of Minesweeper: coordinates of the squares, whether the square contains a mine and the number of mines found on adjacent squares.

51. Let's suppose we're playing Minesweeper on a 5 by 4 grid, i.e.

X = 5

Y = 4

To begin, generate a DataFrame df with two columns, 'x' and 'y' containing every coordinate for this grid. That is, the DataFrame should start:

```
  x y
0 0 0
1 0 1
2 0 2
…
```

```
X = 5
Y = 4

p = pd.core.reshape.util.cartesian_product([np.arange(X), np.arange(Y)])
df = pd.DataFrame(np.asarray(p).T, columns=['x', 'y'])
df
```

52. For this DataFrame df, create a new column of zeros (safe) and ones (mine). The probability of a mine occuring at each location should be 0.4.

```
# One way is to draw samples from a binomial distribution.

df['mine'] = np.random.binomial(1, 0.4, X*Y)
df
```

53. Now create a new column for this DataFrame called 'adjacent'. This column should contain the number of mines found on adjacent squares in the grid.

(E.g. for the first row, which is the entry for the coordinate (0, 0), count how many mines are found on the coordinates (0, 1), (1, 0) and (1, 1).)

```
# Here is one way to solve using merges.
# It's not necessary the optimal way, just
# the solution I thought of first...

df['adjacent'] = \
    df.merge(df + [ 1,  1, 0], on=['x', 'y'], how='left')\
      .merge(df + [ 1, -1, 0], on=['x', 'y'], how='left')\
      .merge(df + [-1,  1, 0], on=['x', 'y'], how='left')\
      .merge(df + [-1, -1, 0], on=['x', 'y'], how='left')\
      .merge(df + [ 1,  0, 0], on=['x', 'y'], how='left')\
      .merge(df + [-1,  0, 0], on=['x', 'y'], how='left')\
      .merge(df + [ 0,  1, 0], on=['x', 'y'], how='left')\
      .merge(df + [ 0, -1, 0], on=['x', 'y'], how='left')\
       .iloc[:, 3:]\
        .sum(axis=1)

# An alternative solution is to pivot the DataFrame
# to form the "actual" grid of mines and use convolution.
# See
https://github.com/jakevdp/matplotlib_pydata2013/blob/master/examples/mines
weeper.py

from scipy.signal import convolve2d

mine_grid = df.pivot_table(columns='x', index='y', values='mine')
counts = convolve2d(mine_grid.astype(complex), np.ones((3, 3)),
mode='same').real.astype(int)
df['adjacent'] = (counts - mine_grid).ravel('F')
```

54. For rows of the DataFrame that contain a mine, set the value in the 'adjacent' column to NaN.

```
df.loc[df['mine'] == 1, 'adjacent'] = np.nan
```

55. Finally, convert the DataFrame to grid of the adjacent mine counts: columns are the x coordinate, rows are the y coordinate.

```
df.drop('mine', axis=1).set_index(['y', 'x']).unstack()
```

Plotting

Visualize trends and patterns in data

Difficulty: *medium*

To really get a good understanding of the data contained in your DataFrame, it is often essential to create plots: if you're lucky, trends and anomalies will jump right out at you. This functionality is baked into pandas and the puzzles below explore some of what's possible with the library.

56. Pandas is highly integrated with the plotting library matplotlib, and makes plotting DataFrames very user-friendly! Plotting in a notebook environment usually makes use of the following boilerplate:

import matplotlib.pyplot **as** plt
%matplotlib inline
plt.style.use('ggplot')

matplotlib is the plotting library which pandas' plotting functionality is built upon, and it is usually aliased to plt.

%matplotlib inline tells the notebook to show plots inline, instead of creating them in a separate window.

plt.style.use('ggplot') is a style theme that most people find agreeable, based upon the styling of R's ggplot package.

For starters, make a scatter plot of this random data, but use black X's instead of the default markers.

df = pd.DataFrame({"xs":[1,5,2,8,1], "ys":[4,2,1,9,6]})

Consult the [documentation]() if you get stuck!

```
import matplotlib.pyplot as plt
%matplotlib inline
plt.style.use('ggplot')

df = pd.DataFrame({"xs":[1,5,2,8,1], "ys":[4,2,1,9,6]})

df.plot.scatter("xs", "ys", color = "black", marker = "x")
```

57. Columns in your DataFrame can also be used to modify colors and sizes. Bill has been keeping track of his performance at work over time, as well as how good he was feeling that day, and whether he had a cup of coffee in the morning. Make a plot which incorporates all four features of this DataFrame.

(Hint: If you're having trouble seeing the plot, try multiplying the Series which you choose to represent size by 10 or more)

The chart doesn't have to be pretty: this isn't a course in data viz!

df = pd.DataFrame({"productivity":[5,2,3,1,4,5,6,7,8,3,4,8,9],

"hours_in" :[1,9,6,5,3,9,2,9,1,7,4,2,2],

"happiness" :[2,1,3,2,3,1,2,3,1,2,2,1,3],

"caffienated" :[0,0,1,1,0,0,0,0,1,1,0,1,0]})

```
df = pd.DataFrame({"productivity":[5,2,3,1,4,5,6,7,8,3,4,8,9],
                   "hours_in"    :[1,9,6,5,3,9,2,9,1,7,4,2,2],
                   "happiness"   :[2,1,3,2,3,1,2,3,1,2,2,1,3],
                   "caffienated" :[0,0,1,1,0,0,0,0,1,1,0,1,0]})
```

```
df.plot.scatter("hours_in", "productivity", s = df.happiness * 30, c =
df.caffienated)
```

58. What if we want to plot multiple things? Pandas allows you to pass in a matplotlib *Axis* object for plots, and plots will also return an Axis object.

Make a bar plot of monthly revenue with a line plot of monthly advertising spending (numbers in millions)

df = pd.DataFrame({"revenue":[57,68,63,71,72,90,80,62,59,51,47,52],

"advertising":[2.1,1.9,2.7,3.0,3.6,3.2,2.7,2.4,1.8,1.6,1.3,1.9],

"month":range(12)

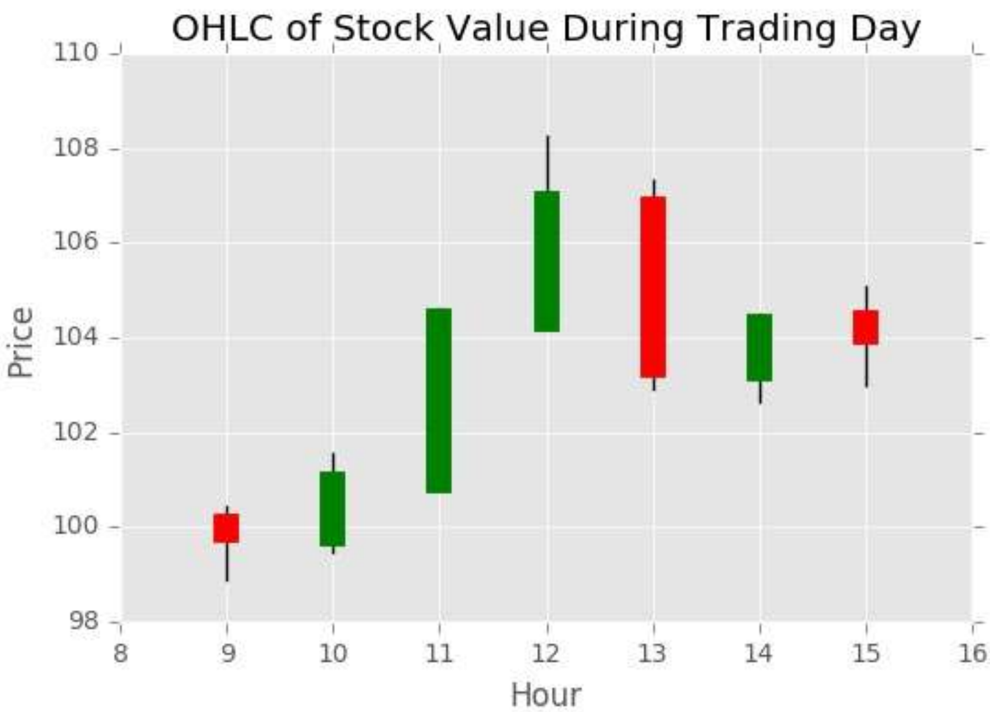
})

```
df = pd.DataFrame({"revenue":[57,68,63,71,72,90,80,62,59,51,47,52],

"advertising":[2.1,1.9,2.7,3.0,3.6,3.2,2.7,2.4,1.8,1.6,1.3,1.9],
                   "month":range(12)
                  })

ax = df.plot.bar("month", "revenue", color = "green")
df.plot.line("month", "advertising", secondary_y = True, ax = ax)
ax.set_xlim((-1,12))
```

Now we're finally ready to create a candlestick chart, which is a very common tool used to analyze stock price data. A candlestick chart shows the opening, closing, highest, and lowest price for a stock during a time window. The color of the "candle" (the thick part of the bar) is green if the stock closed above its opening price, or red if below.



This was initially designed to be a pandas plotting challenge, but it just so happens that this type of plot is just not feasible using pandas' methods. If you are unfamiliar with matplotlib, we have provided a function that will plot the chart for you so long as you can use pandas to get the data into the correct format.

Your first step should be to get the data in the correct format using pandas' time-series grouping function. We would like each candle to represent an hour's worth of data. You can write your own aggregation function which returns the open/high/low/close, but pandas has a built-in which also does this.

The below cell contains helper functions. Call day_stock_data() to generate a DataFrame containing the prices a hypothetical stock sold for, and the time the sale occurred. Call plot_candlestick(df) on your properly aggregated and formatted stock data to print the candlestick chart.

```
import numpy as np
def float_to_time(x):
    return str(int(x)) + ":" + str(int(x%1 * 60)).zfill(2) + ":" +
str(int(x*60 % 1 * 60)).zfill(2)

def day_stock_data():
    #NYSE is open from 9:30 to 4:00
    time = 9.5
    price = 100
    results = [(float_to_time(time), price)]
    while time < 16:
        elapsed = np.random.exponential(.001)
        time += elapsed
        if time > 16:
            break
        price_diff = np.random.uniform(.999, 1.001)
        price *= price_diff
        results.append((float_to_time(time), price))


    df = pd.DataFrame(results, columns = ['time','price'])
    df.time = pd.to_datetime(df.time)
    return df

def plot_candlestick(agg):
    fig, ax = plt.subplots()
    for time in agg.index:
        ax.plot([time.hour] * 2, agg.loc[time, ["high","low"]].values,
color = "black")
        ax.plot([time.hour] * 2, agg.loc[time, ["open","close"]].values,
color = agg.loc[time, "color"], linewidth = 10)

    ax.set_xlim((8,16))
    ax.set_ylabel("Price")
    ax.set_xlabel("Hour")
    ax.set_title("OHLC of Stock Value During Trading Day")
    plt.show()
```

59. Generate a day's worth of random stock data, and aggregate / reformat it so that it has hourly summaries of the opening, highest, lowest, and closing prices

```
df = day_stock_data()
df.head()
```

```
df.set_index("time", inplace = True)
```

```
agg = df.resample("H").ohlc()
agg.columns = agg.columns.droplevel()
agg["color"] = (agg.close > agg.open).map({True:"green",False:"red"})
agg.head()
```

60. Now that you have your properly-formatted data, try to plot it yourself as a candlestick chart. Use the plot_candlestick(df) function above, or matplotlib's plot documentation if you get stuck.

```
plot_candlestick(agg)
```