mod3

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0.1 CBA Marathon Courses Fall 2018

1 Data Analysis and Visualization Using Python

1.1 Module 3 - Pandas

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2 Introduction to Pandas

- It is a python 3rd party library
- Used for data analysis and visualization
- Part of Anaconda python distribution
- Best used with Jupyter notebook, can be used with regular python programs
- Main feature is the Data Frame

```
In [1]: # Load the pandas library to let python know you will use it
        import pandas as pd
```

3 What is a Data Frame?

- Its a data structure, like lists and dictionaries
- Consists of rows and columns, similar to SQL tables and excel spreadsheets
- Columns are attributes or variables
- Rows are records or single observations
- Operations are typically performed on columns
- Has both numeric and named indexing

4 Tidy Data

- Standard form of organizing data in dataframe such that:
  - Each variable forms a column
  - Each row forms a row
  - Each table is an observational unit (level of analysis)
- Required reading: Tidy Data, by Hadley Wickham

5 Untidy/messy data can have

- Missing column names
- Aggregate/duplicate data
- Values for different variables in same column
- Data that should be on multiple tables is fitted into a single table
- ...more

6 Example of untidy/messy data

ID	Variable Name	Value
1	width	10
1	length	12
1	color	red
2	width	3
2	length	5
2	color	green

7 Example of tidy data

ID	width	length	color
1	10	12	red
2	3	5	green

8 Importance of Tidy Data

- Most tools we will use assume that data is tidy
- Collected data is likely messy or non-tidy, need to learn how to reshape it
- We will start with tidy data in our analysis
  - Will learn how to reshape when we start data collection

9 Loading data into a data frame

- Data is usually loaded/collected from an external source, like an api, website, csv, or excel file, and might not be well organized.
  - We will start with well organized and behaved data to get to know how to use Pandas
- Download the weather data set from vega-dataset (**right click and save as**)
- Place it in the same directory as the jupyter notbook you are working on

```
In [5]: # load the data using pandas library
        # do you remember what was pd?
```

```
pd.read_csv("weather.csv")

# Jupter notebook tip:
# type: pd.
# then hit tab, see what happens
# try also: pd.read_ (then hit tab)
```

Out[5]:

```
      location              date  precipitation  temp_max  temp_min  wind  \
0      Seattle  2012-01-01 00:00            0.0      12.8       5.0   4.7   
1      Seattle  2012-01-02 00:00           10.9      10.6       2.8   4.5   
2      Seattle  2012-01-03 00:00            0.8      11.7       7.2   2.3   
3      Seattle  2012-01-04 00:00           20.3      12.2       5.6   4.7   
4      Seattle  2012-01-05 00:00            1.3       8.9       2.8   6.1   
5      Seattle  2012-01-06 00:00            2.5       4.4       2.2   2.2   
6      Seattle  2012-01-07 00:00            0.0       7.2       2.8   2.3   
7      Seattle  2012-01-08 00:00            0.0      10.0       2.8   2.0   
8      Seattle  2012-01-09 00:00            4.3       9.4       5.0   3.4   
9      Seattle  2012-01-10 00:00            1.0       6.1       0.6   3.4   
10     Seattle  2012-01-11 00:00            0.0       6.1      -1.1   5.1   
11     Seattle  2012-01-12 00:00            0.0       6.1      -1.7   1.9   
12     Seattle  2012-01-13 00:00            0.0       5.0      -2.8   1.3   
13     Seattle  2012-01-14 00:00            4.1       4.4       0.6   5.3   
14     Seattle  2012-01-15 00:00            5.3       1.1      -3.3   3.2   
15     Seattle  2012-01-16 00:00            2.5       1.7      -2.8   5.0   
16     Seattle  2012-01-17 00:00            8.1       3.3       0.0   5.6   
17     Seattle  2012-01-18 00:00           19.8       0.0      -2.8   5.0   
18     Seattle  2012-01-19 00:00           15.2      -1.1      -2.8   1.6   
19     Seattle  2012-01-20 00:00           13.5       7.2      -1.1   2.3   
20     Seattle  2012-01-21 00:00            3.0       8.3       3.3   8.2   
21     Seattle  2012-01-22 00:00            6.1       6.7       2.2   4.8   
22     Seattle  2012-01-23 00:00            0.0       8.3       1.1   3.6   
23     Seattle  2012-01-24 00:00            8.6      10.0       2.2   5.1   
24     Seattle  2012-01-25 00:00            8.1       8.9       4.4   5.4   
25     Seattle  2012-01-26 00:00            4.8       8.9       1.1   4.8   
26     Seattle  2012-01-27 00:00            0.0       6.7      -2.2   1.4   
27     Seattle  2012-01-28 00:00            0.0       6.7       0.6   2.2   
28     Seattle  2012-01-29 00:00           27.7       9.4       3.9   4.5   
29     Seattle  2012-01-30 00:00            3.6       8.3       6.1   5.1   
...        ...               ...            ...       ...       ...   ...   
2892  New York  2015-12-02 00:00            3.0      13.9       8.3   2.0   
2893  New York  2015-12-03 00:00            0.0      13.3       7.2   7.2   
2894  New York  2015-12-04 00:00            0.0      11.7       5.0   4.7   
2895  New York  2015-12-05 00:00            0.0      11.7       1.7   2.4   
2896  New York  2015-12-06 00:00            0.0      10.6       3.3   2.9   
2897  New York  2015-12-07 00:00            0.0      12.8       4.4   3.4   
2898  New York  2015-12-08 00:00            0.0      10.6       4.4   3.5   
2899  New York  2015-12-09 00:00            0.0      12.8       1.1   3.4   
2900  New York  2015-12-10 00:00            0.0      15.0       8.9   3.0   
```

```
2901  New York  2015-12-11 00:00            0.0      14.4       7.8   2.7
2902  New York  2015-12-12 00:00            0.0      17.8       9.4   1.9
2903  New York  2015-12-13 00:00            0.0      21.1      11.7   3.1
2904  New York  2015-12-14 00:00            9.1      16.1      11.7   4.8
2905  New York  2015-12-15 00:00            2.3      17.8      11.7   8.2
2906  New York  2015-12-16 00:00            1.3      11.7       7.2   4.1
2907  New York  2015-12-17 00:00           29.7      15.0      10.0   4.1
2908  New York  2015-12-18 00:00            0.3      14.4       3.9   6.1
2909  New York  2015-12-19 00:00            0.0       5.0       2.2   9.0
2910  New York  2015-12-20 00:00            0.0       6.7       1.7   5.1
2911  New York  2015-12-21 00:00            0.0      12.8       3.3   5.3
2912  New York  2015-12-22 00:00            4.8      15.6      11.1   3.8
2913  New York  2015-12-23 00:00           29.5      17.2       8.9   4.5
2914  New York  2015-12-24 00:00            0.5      20.6      13.9   4.9
2915  New York  2015-12-25 00:00            2.5      17.8      11.1   0.9
2916  New York  2015-12-26 00:00            0.3      15.6       9.4   4.8
2917  New York  2015-12-27 00:00            2.0      17.2       8.9   5.5
2918  New York  2015-12-28 00:00            1.3       8.9       1.7   6.3
2919  New York  2015-12-29 00:00           16.8       9.4       1.1   5.3
2920  New York  2015-12-30 00:00            9.4      10.6       5.0   3.0
2921  New York  2015-12-31 00:00            1.5      11.1       6.1   5.5

      weather
0     drizzle
1        rain
2        rain
3        rain
4        rain
5        rain
6        rain
7         sun
8        rain
9        rain
10        sun
11        sun
12        sun
13       snow
14       snow
15       snow
16       snow
17       snow
18       snow
19       snow
20       rain
21       rain
22       rain
23       rain
24       rain
```

```
25       rain
26    drizzle
27       rain
28       rain
29       rain
...       ...
2892      fog
2893      sun
2894      sun
2895      sun
2896      sun
2897  drizzle
2898      sun
2899      sun
2900  drizzle
2901  drizzle
2902      fog
2903  drizzle
2904      fog
2905      fog
2906      fog
2907      fog
2908      sun
2909      sun
2910      sun
2911      sun
2912      fog
2913      fog
2914      fog
2915      fog
2916  drizzle
2917      fog
2918     snow
2919      fog
2920      fog
2921      fog

[2922 rows x 7 columns]
```

10 Loading File From URL

If the CSV file is downloadable from a url, you can put the URL in place of the file name:

```
In [5]: my_df = pd.read_csv("https://raw.githubusercontent.com/vega/vega-datasets/gh-pages/data
        my_df
```

```
Out[5]:       location        date  precipitation  temp_max  temp_min  wind  weather
        0      Seattle  2012-01-01            0.0      12.8       5.0   4.7  drizzle
```

```
1     Seattle  2012-01-02          10.9      10.6       2.8  4.5     rain
2     Seattle  2012-01-03           0.8      11.7       7.2  2.3     rain
3     Seattle  2012-01-04          20.3      12.2       5.6  4.7     rain
4     Seattle  2012-01-05           1.3       8.9       2.8  6.1     rain
5     Seattle  2012-01-06           2.5       4.4       2.2  2.2     rain
6     Seattle  2012-01-07           0.0       7.2       2.8  2.3     rain
7     Seattle  2012-01-08           0.0      10.0       2.8  2.0      sun
8     Seattle  2012-01-09           4.3       9.4       5.0  3.4     rain
9     Seattle  2012-01-10           1.0       6.1       0.6  3.4     rain
10    Seattle  2012-01-11           0.0       6.1      -1.1  5.1      sun
11    Seattle  2012-01-12           0.0       6.1      -1.7  1.9      sun
12    Seattle  2012-01-13           0.0       5.0      -2.8  1.3      sun
13    Seattle  2012-01-14           4.1       4.4       0.6  5.3     snow
14    Seattle  2012-01-15           5.3       1.1      -3.3  3.2     snow
15    Seattle  2012-01-16           2.5       1.7      -2.8  5.0     snow
16    Seattle  2012-01-17           8.1       3.3       0.0  5.6     snow
17    Seattle  2012-01-18          19.8       0.0      -2.8  5.0     snow
18    Seattle  2012-01-19          15.2      -1.1      -2.8  1.6     snow
19    Seattle  2012-01-20          13.5       7.2      -1.1  2.3     snow
20    Seattle  2012-01-21           3.0       8.3       3.3  8.2     rain
21    Seattle  2012-01-22           6.1       6.7       2.2  4.8     rain
22    Seattle  2012-01-23           0.0       8.3       1.1  3.6     rain
23    Seattle  2012-01-24           8.6      10.0       2.2  5.1     rain
24    Seattle  2012-01-25           8.1       8.9       4.4  5.4     rain
25    Seattle  2012-01-26           4.8       8.9       1.1  4.8     rain
26    Seattle  2012-01-27           0.0       6.7      -2.2  1.4  drizzle
27    Seattle  2012-01-28           0.0       6.7       0.6  2.2     rain
28    Seattle  2012-01-29          27.7       9.4       3.9  4.5     rain
29    Seattle  2012-01-30           3.6       8.3       6.1  5.1     rain
...       ...         ...           ...       ...       ...  ...      ...
2892 New York  2015-12-02           3.0      13.9       8.3  2.0      fog
2893 New York  2015-12-03           0.0      13.3       7.2  7.2      sun
2894 New York  2015-12-04           0.0      11.7       5.0  4.7      sun
2895 New York  2015-12-05           0.0      11.7       1.7  2.4      sun
2896 New York  2015-12-06           0.0      10.6       3.3  2.9      sun
2897 New York  2015-12-07           0.0      12.8       4.4  3.4  drizzle
2898 New York  2015-12-08           0.0      10.6       4.4  3.5      sun
2899 New York  2015-12-09           0.0      12.8       1.1  3.4      sun
2900 New York  2015-12-10           0.0      15.0       8.9  3.0  drizzle
2901 New York  2015-12-11           0.0      14.4       7.8  2.7  drizzle
2902 New York  2015-12-12           0.0      17.8       9.4  1.9      fog
2903 New York  2015-12-13           0.0      21.1      11.7  3.1  drizzle
2904 New York  2015-12-14           9.1      16.1      11.7  4.8      fog
2905 New York  2015-12-15           2.3      17.8      11.7  8.2      fog
2906 New York  2015-12-16           1.3      11.7       7.2  4.1      fog
2907 New York  2015-12-17          29.7      15.0      10.0  4.1      fog
2908 New York  2015-12-18           0.3      14.4       3.9  6.1      sun
2909 New York  2015-12-19           0.0       5.0       2.2  9.0      sun
```

```
2910  New York  2015-12-20            0.0        6.7        1.7  5.1      sun
2911  New York  2015-12-21            0.0       12.8        3.3  5.3      sun
2912  New York  2015-12-22            4.8       15.6       11.1  3.8      fog
2913  New York  2015-12-23           29.5       17.2        8.9  4.5      fog
2914  New York  2015-12-24            0.5       20.6       13.9  4.9      fog
2915  New York  2015-12-25            2.5       17.8       11.1  0.9      fog
2916  New York  2015-12-26            0.3       15.6        9.4  4.8  drizzle
2917  New York  2015-12-27            2.0       17.2        8.9  5.5      fog
2918  New York  2015-12-28            1.3        8.9        1.7  6.3     snow
2919  New York  2015-12-29           16.8        9.4        1.1  5.3      fog
2920  New York  2015-12-30            9.4       10.6        5.0  3.0      fog
2921  New York  2015-12-31            1.5       11.1        6.1  5.5      fog

[2922 rows x 7 columns]
```

11 Now it is your turn

Download airport.csv then load it into the notebook

Remember: Right click on the link and select **save target as**

```
In [ ]:
```

12 File Types

- CSV: Comma Separated Values example
  - Use pd.read_csv
- JSON: Javascript Object Notation example
  - Use pd.read_json
- Excel: Microsoft Excel File
  - Use pd.read_excel
- Others, type pd.read_ then hit Tab to see a list

```
In [ ]: # Your turn
        # Load: https://github.com/vega/vega-datasets/raw/gh-pages/data/cars.json
        # Into: cars_df
```

13 How to work with the data?

- You must place it in a variable so you can refer to it
- The current data was displayed and not assigned to a variable, so you cannot use it
- Assign it to a variable named **my_df**

```
In [3]: my_df = pd.read_csv("weather.csv")
```

```
In [ ]: # Your turn: Load airports.csv into airports_df
```

14 Let us discover how the data looks like

We examine the top and bottom records of the dataframe to get an idea of what the data looks like

```
In [9]: my_df.head()
```

```
Out[9]:   location              date  precipitation  temp_max  temp_min  wind  weather
        0  Seattle  2012-01-01 00:00            0.0      12.8       5.0   4.7  drizzle
        1  Seattle  2012-01-02 00:00           10.9      10.6       2.8   4.5     rain
        2  Seattle  2012-01-03 00:00            0.8      11.7       7.2   2.3     rain
        3  Seattle  2012-01-04 00:00           20.3      12.2       5.6   4.7     rain
        4  Seattle  2012-01-05 00:00            1.3       8.9       2.8   6.1     rain
```

```
In [ ]: # You can pass a number in the head() method to show more data
        # show 10 items (try it)

        # do the same for airports_df
```

```
In [13]: # To know which columns are available use the columns attribute
         my_df.columns
```

```
Out[13]: Index(['location', 'date', 'precipitation', 'temp_max', 'temp_min', 'wind',
                'weather'],
               dtype='object')
```

```
In [ ]: # Your turn: explore the columns for airports_df
```

15 Data types

- Each **column** will have its own data type
- Remember, variables will be in columns
- Observations in rows
- Use dtypes attribute of to discover columns and datatypes
- **OOP**: What is the difference between a *function*, a *method*, an *attribute*, and a *variable*?

```
In [18]: my_df.dtypes
```

```
Out[18]: location          object
         date              object
         precipitation    float64
         temp_max         float64
         temp_min         float64
         wind             float64
         weather           object
         dtype: object
```

```
In [ ]: # Your turn: Find out the data types for the airports_df column
In [18]: # Pandas uses data types provided by numpy
         # load numpy
         import numpy as np

         # convert the column to datetime
         my_df.date.astype(np.datetime64)
```

```
Out[18]: 0      2012-01-01
         1      2012-01-02
         2      2012-01-03
         3      2012-01-04
         4      2012-01-05
         5      2012-01-06
         6      2012-01-07
         7      2012-01-08
         8      2012-01-09
         9      2012-01-10
         10     2012-01-11
         11     2012-01-12
         12     2012-01-13
         13     2012-01-14
         14     2012-01-15
         15     2012-01-16
         16     2012-01-17
         17     2012-01-18
         18     2012-01-19
         19     2012-01-20
         20     2012-01-21
         21     2012-01-22
         22     2012-01-23
         23     2012-01-24
         24     2012-01-25
         25     2012-01-26
         26     2012-01-27
         27     2012-01-28
         28     2012-01-29
         29     2012-01-30
                   ...
         2892   2015-12-02
         2893   2015-12-03
         2894   2015-12-04
         2895   2015-12-05
         2896   2015-12-06
         2897   2015-12-07
         2898   2015-12-08
         2899   2015-12-09
         2900   2015-12-10
         2901   2015-12-11
```

```
 2902   2015-12-12
 2903   2015-12-13
 2904   2015-12-14
 2905   2015-12-15
 2906   2015-12-16
 2907   2015-12-17
 2908   2015-12-18
 2909   2015-12-19
 2910   2015-12-20
 2911   2015-12-21
 2912   2015-12-22
 2913   2015-12-23
 2914   2015-12-24
 2915   2015-12-25
 2916   2015-12-26
 2917   2015-12-27
 2918   2015-12-28
 2919   2015-12-29
 2920   2015-12-30
 2921   2015-12-31
 Name: date, dtype: datetime64[ns]
```

```
In [5]: # an alternative way to do it is using
        pd.to_datetime(my_df.date).head() # do you remember head method?
```

```
Out[5]: 0   2012-01-01
        1   2012-01-02
        2   2012-01-03
        3   2012-01-04
        4   2012-01-05
        Name: date, dtype: datetime64[ns]
```

```
In [6]: # now let us examine the date column
        my_df.date.head()

        # why is it still of type object?
        # How to fix it?
```

```
Out[6]: 0    2012-01-01 00:00
        1    2012-01-02 00:00
        2    2012-01-03 00:00
        3    2012-01-04 00:00
        4    2012-01-05 00:00
        Name: date, dtype: object
```

```
In [ ]: # just like the dataframe, the command creates a copy
        # but does not store it
        # We need to replace the old date column with the new one
        my_df.date = my_df.date.astype(np.datetime64)
```

```
In [23]: # check the types
         my_df.dtypes

Out[23]: location                  object
         date              datetime64[ns]
         precipitation            float64
         temp_max                 float64
         temp_min                 float64
         wind                     float64
         weather                   object
         dtype: object
```

```
In [2]: # Your turn: examine the airports_df dataframe
        # are there any date columns that you can convert?
        # Check then numeric columns, what should their data type be?
```

16 Data Types and Variable Types

Variable Type	Data Type
Continuous	float64, datetime64[ns]
Discrete	int64
Ordinal	int64, category
Nominal	int64, object, category
Categorical	int64, object, category

17 Why convert an object column into a date column?

- As you will find out later, pandas can do more fancy things if it knows the column is a date
- For example:
- Sort
- Filter based on date range
- Date arethmatic
- Always make sure date/time columns have the correct data type

18 Indexing Columns

- Using square brackets [ ]
- Using dot notation .

```
In [7]: # a single column is known as a series
        my_df['location']

Out[7]: 0        Seattle
        1        Seattle
        2        Seattle
```

```
3        Seattle
4        Seattle
5        Seattle
6        Seattle
7        Seattle
8        Seattle
9        Seattle
10       Seattle
11       Seattle
12       Seattle
13       Seattle
14       Seattle
15       Seattle
16       Seattle
17       Seattle
18       Seattle
19       Seattle
20       Seattle
21       Seattle
22       Seattle
23       Seattle
24       Seattle
25       Seattle
26       Seattle
27       Seattle
28       Seattle
29       Seattle
          ...
2892    New York
2893    New York
2894    New York
2895    New York
2896    New York
2897    New York
2898    New York
2899    New York
2900    New York
2901    New York
2902    New York
2903    New York
2904    New York
2905    New York
2906    New York
2907    New York
2908    New York
2909    New York
2910    New York
2911    New York
```

```
        2912    New York
        2913    New York
        2914    New York
        2915    New York
        2916    New York
        2917    New York
        2918    New York
        2919    New York
        2920    New York
        2921    New York
        Name: location, dtype: object
```

```
In [8]: # Some methods that work on Dataframes also work on Series
        my_df['location'].head()
```

```
Out[8]: 0    Seattle
        1    Seattle
        2    Seattle
        3    Seattle
        4    Seattle
        Name: location, dtype: object
```

```
In [13]: # Dot notation to access series
         my_df.location.head()
```

```
Out[13]: 0    Seattle
         1    Seattle
         2    Seattle
         3    Seattle
         4    Seattle
         Name: location, dtype: object
```

```
In [ ]: # Your turn: Try to index the columns for airports_df using square brackets and dot no
        # Use head() to get an idea of what the data is
```

```
In [14]: # Descriptive statistics
         my_df['location'].describe()
```

```
Out[14]: count         2922
         unique           2
         top       New York
         freq          1461
         Name: location, dtype: object
```

```
In [15]: # works also on dataframe
         my_df.describe()
```

```
Out[15]:        precipitation     temp_max     temp_min         wind
         count    2922.000000  2922.000000  2922.000000  2922.000000
```

```
mean        2.944764    16.769131     8.612320     4.101129
std         7.695286     8.644596     7.511776     1.880791
min         0.000000    -7.700000   -16.000000     0.400000
25%         0.000000    10.000000     3.300000     2.700000
50%         0.000000    16.100000     8.900000     3.800000
75%         1.800000    23.900000    13.900000     5.100000
max       118.900000    37.800000    26.700000    16.200000
```

```
In [26]: # Different data types will have different descriptives
         my_df['date'].describe()
```

```
Out[26]: count                     2922
         unique                    1461
         top       2013-06-05 00:00:00
         freq                         2
         first     2012-01-01 00:00:00
         last      2015-12-31 00:00:00
         Name: date, dtype: object
```

```
In [21]: my_df.precipitation.describe()
```

```
Out[21]: count    2922.000000
         mean        2.944764
         std         7.695286
         min         0.000000
         25%         0.000000
         50%         0.000000
         75%         1.800000
         max       118.900000
         Name: precipitation, dtype: float64
```

```
In [ ]: # Your turn: Use describe() on airports_df

        # Which columns are included in describe?

        # Try it on the columns that were excluded:

        # Why were these columns excluded?
```

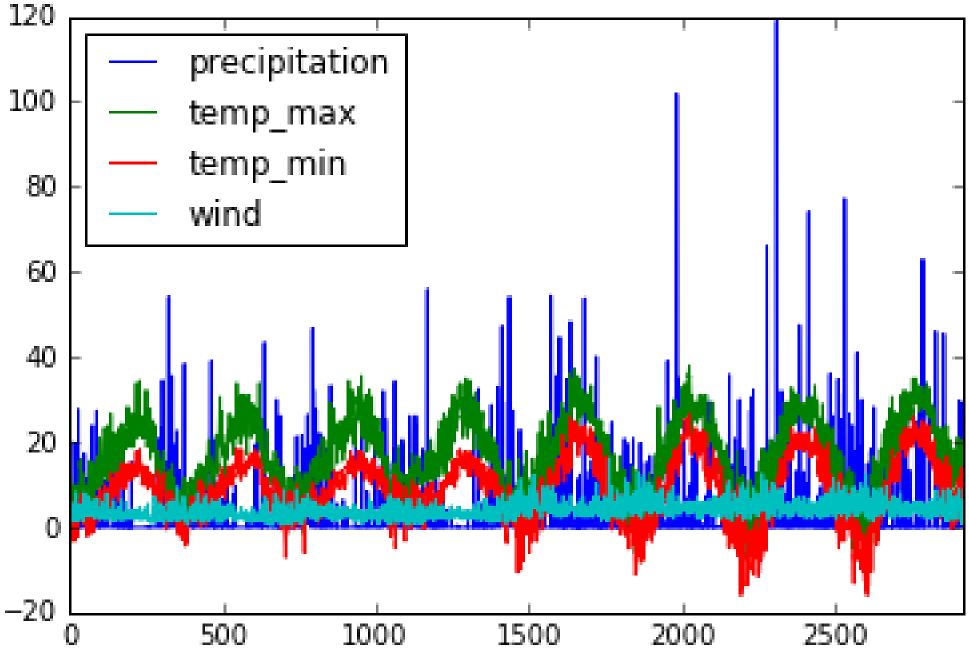
19 You can also plot a dataframe

- Pandas will try to show it in the best way possible
- Plotting from dataframe is very simplistic and used for quick univariate exploration

```
In [ ]: my_df.plot()
```

```
In [29]: # You need to tell pandas that you want to display plots in the notebook
         %matplotlib inline
```

```
In [31]: # now try it
         my_df.plot()

Out[31]: <matplotlib.axes._subplots.AxesSubplot at 0x1147020b8>
```

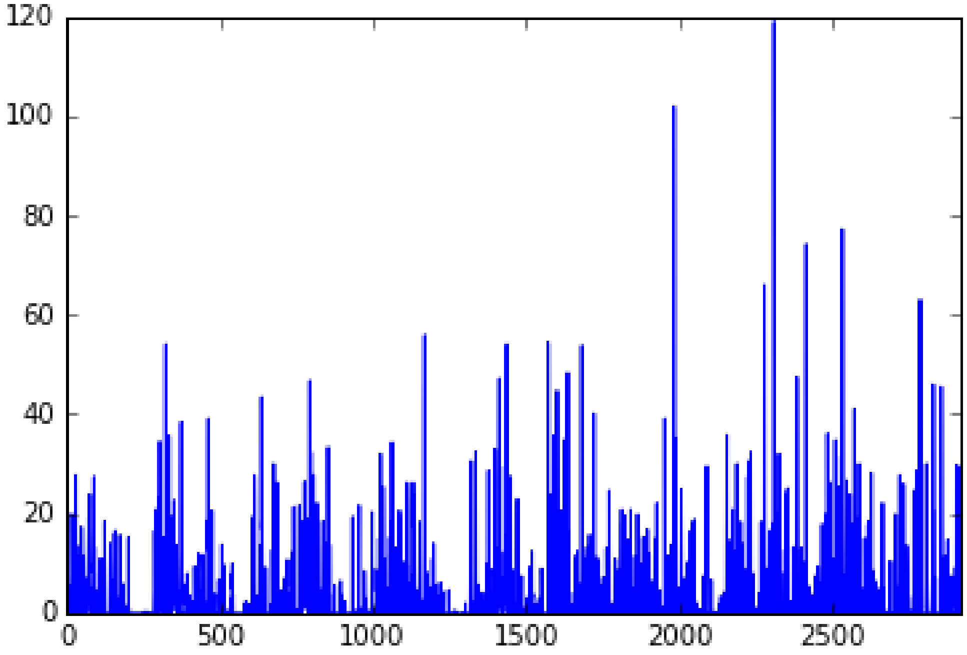


20 Don't forget!

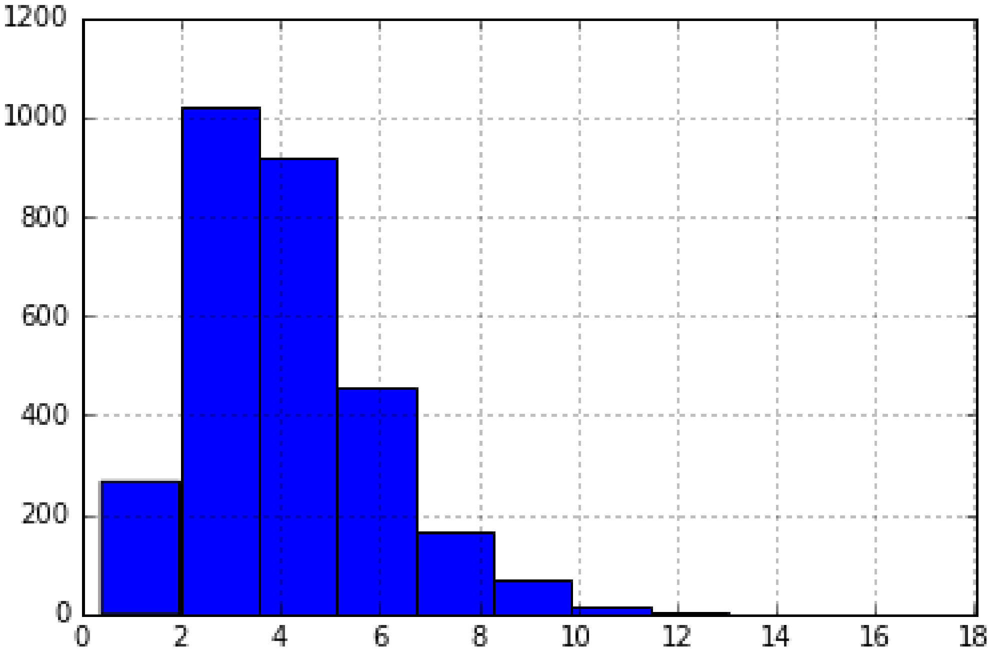
Always include in your notebook:

```
# this is the first cell in your notebook
import pandas as pd
%matplotlib inline    # dont forget this
```

```
In [32]: # It's more meaningful to plot Series
         my_df['precipitation'].plot()

Out[32]: <matplotlib.axes._subplots.AxesSubplot at 0x1147250f0>
```



```
In [9]: # Remember plots show change from one observation to the next
        my_df['wind'].plot()

        # in some cases it might not be useful

Out[9]: <matplotlib.axes._subplots.AxesSubplot at 0x10b33f710>

In [40]: # you can try a histogram
         my_df['wind'].hist()

         # Which is useful to know distributions

Out[40]: <matplotlib.axes._subplots.AxesSubplot at 0x116d89240>
```



21 How can you find out if percipitation is usually high in the year or low?

```
In [ ]: # Your turn:
```

```
In [45]: # Sometime pandas cannot plot it
         my_df['location'].plot()
```

```
        ---------------------------------------------------------------------------

        TypeError                                 Traceback (most recent call last)

        <ipython-input-45-e083b00ff51a> in <module>()
          1 # Sometime pandas cannot plot it
    ----> 2 my_df['location'].plot()


        /Users/koutbo6/anaconda/lib/python3.5/site-packages/pandas/tools/plotting.py in __call_
       3564                              colormap=colormap, table=table, yerr=yerr,
       3565                              xerr=xerr, label=label, secondary_y=secondary_y,
    -> 3566                              **kwds)
       3567     __call__.__doc__ = plot_series.__doc__
       3568
```

```
 /Users/koutbo6/anaconda/lib/python3.5/site-packages/pandas/tools/plotting.py in plot_s
   2643                     yerr=yerr, xerr=xerr,
   2644                     label=label, secondary_y=secondary_y,
-> 2645                     **kwds)
   2646
   2647


 /Users/koutbo6/anaconda/lib/python3.5/site-packages/pandas/tools/plotting.py in _plot(
   2439         plot_obj = klass(data, subplots=subplots, ax=ax, kind=kind, **kwds)
   2440
-> 2441     plot_obj.generate()
   2442     plot_obj.draw()
   2443     return plot_obj.result


 /Users/koutbo6/anaconda/lib/python3.5/site-packages/pandas/tools/plotting.py in genera
   1024     def generate(self):
   1025         self._args_adjust()
-> 1026         self._compute_plot_data()
   1027         self._setup_subplots()
   1028         self._make_plot()


 /Users/koutbo6/anaconda/lib/python3.5/site-packages/pandas/tools/plotting.py in _compu
   1133         if is_empty:
   1134             raise TypeError('Empty {0!r}: no numeric data to '
-> 1135                             'plot'.format(numeric_data.__class__.__name__))
   1136
   1137         self.data = numeric_data


 TypeError: Empty 'DataFrame': no numeric data to plot
```

```
In [ ]: # Your turn: try to plot the columns in airport_df using either plot() or hist()


        # What can you find out about the data?
```

```
In [49]: # Such variables are usually categorical and you can get frequencies like so
          my_df['location'].value_counts()
```

```
Out[49]: New York    1461
         Seattle     1461
         Name: location, dtype: int64
```

```
In [3]: # Your turn: Examine the columns for airports_df
        # what would be the best columns to check frequencies for?
        # try it:


        # The best columns are:

        # The reason frequencies is best calculated on them is because:

        # What did you find out about your data?

        # try to plot value_count(), how do you do it? what do you get?
```

22 Are data frames immutable?

- Yes, however, all operations that change values will produce a copy and not change the original
- You have to use assignment to change columns or dataframes
- **So be careful!**

23 Missing Value (Nulls or Nans)

- Missing values are usually represented by:
  - The Python Null if the value doesn't exists
  - Numpy nan if the value is Not a Number (like zero division)
- Use .dropna() to remove rows with null values or .fillna() to replace the values

```
In [9]: # what are we doing here?
        cars_df = pd.read_json("https://github.com/vega/vega-datasets/raw/gh-pages/data/cars.j

        # What are we doing here?
        len(cars_df)

Out[9]: 406

In [10]: # Why do we have a smaller value now?
         len(cars_df.dropna())

Out[10]: 392

In [11]: # let's look at the available columns
         cars_df.columns

Out[11]: Index(['Acceleration', 'Cylinders', 'Displacement', 'Horsepower',
                'Miles_per_Gallon', 'Name', 'Origin', 'Weight_in_lbs', 'Year'],
               dtype='object')
```

```
In [27]: # You can limit checking null values to specific columns
         len(cars_df.dropna(subset=['Miles_per_Gallon','Horsepower',]))

Out[27]: 392

In [28]: # condition can be that all are missing
         len(cars_df.dropna(subset=['Miles_per_Gallon','Horsepower',], how="all"))

Out[28]: 406

In [29]: # or at least one
         len(cars_df.dropna(subset=['Miles_per_Gallon','Horsepower',], how="any"))

Out[29]: 392

In [33]: # You can also choose to replace the nulls with a value
         # like the mean or 0 depending on what makes more sense
         cars_df.fillna(0).head()

Out[33]:    Acceleration  Cylinders  Displacement  Horsepower  Miles_per_Gallon  \
         0          12.0          8         307.0       130.0              18.0
         1          11.5          8         350.0       165.0              15.0
         2          11.0          8         318.0       150.0              18.0
         3          12.0          8         304.0       150.0              16.0
         4          10.5          8         302.0       140.0              17.0

                                 Name Origin  Weight_in_lbs        Year
         0  chevrolet chevelle malibu    USA           3504  1970-01-01
         1          buick skylark 320    USA           3693  1970-01-01
         2         plymouth satellite    USA           3436  1970-01-01
         3              amc rebel sst    USA           3433  1970-01-01
         4                ford torino    USA           3449  1970-01-01

In [35]: # you can also specify which column gets which value using a dictionary
         cars_df.fillna(
             {
                 'Miles_per_Gallon':0, # put 0 instead of null in miled_per_gallon
                 'Horsepower':cars_df.Horsepower.mean(), # put mean instead of null in horsepo
             }
         ).head()

Out[35]:    Acceleration  Cylinders  Displacement  Horsepower  Miles_per_Gallon  \
         0          12.0          8         307.0       130.0              18.0
         1          11.5          8         350.0       165.0              15.0
         2          11.0          8         318.0       150.0              18.0
         3          12.0          8         304.0       150.0              16.0
         4          10.5          8         302.0       140.0              17.0

                                 Name Origin  Weight_in_lbs        Year
```

```
0  chevrolet chevelle malibu    USA             3504  1970-01-01
1          buick skylark 320    USA             3693  1970-01-01
2         plymouth satellite    USA             3436  1970-01-01
3              amc rebel sst    USA             3433  1970-01-01
4                ford torino    USA             3449  1970-01-01
```

24 Duplicates

- Search for any repeated values
- use duplicated()
  - Note that this looks at all the columns in the record
  - You can pass a list of column names to check duplication based on

```
In [28]: my_df.duplicated()
```

```
Out[28]: 0        False
         1        False
         2        False
         3        False
         4        False
         5        False
         6        False
         7        False
         8        False
         9        False
         10       False
         11       False
         12       False
         13       False
         14       False
         15       False
         16       False
         17       False
         18       False
         19       False
         20       False
         21       False
         22       False
         23       False
         24       False
         25       False
         26       False
         27       False
         28       False
         29       False
                  ...
         2892     False
         2893    False
         2894    False
         2895    False
         2896    False
         2897    False
         2898    False
         2899    False
         2900    False
         2901    False
         2902    False
         2903    False
         2904    False
         2905    False
         2906    False
         2907    False
         2908    False
         2909    False
         2910    False
         2911    False
         2912    False
         2913    False
         2914    False
         2915    False
         2916    False
         2917    False
         2918    False
         2919    False
         2920    False
         2921    False
         dtype: bool
```

```
In [33]: # Try to pass location as the duplication column and see what happens
         my_df.duplicated("location").value_counts()

         # what is value_counts?
```

```
Out[33]: True     2920
         False       2
         dtype: int64
```

```
In [34]: # now try it with both location and weather columns
         my_df.duplicated(["location", "weather"]).value_counts()
```

```
Out[34]: True     2912
         False      10
         dtype: int64
```

```
In [39]: # You can also remove duplicates using .drop_duplicates
         len(my_df)
```

```
Out[39]: 2922
```

```
In [38]: # there are no duplicates of all the values
         len(my_df.drop_duplicates())
```

```
Out[38]: 2922
```

```
In [40]: # You want to get the different weather that each location would get
         # without any duplication
         len(my_df.drop_duplicates(subset=["location", "weather"]))
```

```
Out[40]: 10
```

```
In [41]: # The first entry will be selected for each location and weather combination
         my_df.drop_duplicates(subset=["location", "weather"])
```

```
Out[41]:       location        date  precipitation  temp_max  temp_min  wind  weather
         0      Seattle  2012-01-01            0.0      12.8       5.0   4.7  drizzle
         1      Seattle  2012-01-02           10.9      10.6       2.8   4.5     rain
         7      Seattle  2012-01-08            0.0      10.0       2.8   2.0      sun
         13     Seattle  2012-01-14            4.1       4.4       0.6   5.3     snow
         192    Seattle  2012-07-11            0.0      27.8      13.3   2.9      fog
         1461  New York  2012-01-01            1.8      10.0       3.3   5.1     rain
         1462  New York  2012-01-02            0.0      10.0       0.6   8.7      sun
         1470  New York  2012-01-10            0.0       8.9      -1.1   5.5  drizzle
         1473  New York  2012-01-13            0.0      10.0      -1.7  11.4     snow
         1539  New York  2012-03-19            0.0      17.8       7.2   3.1      fog
```

```
In [43]: # you can even show the location and whather only using indexing
         my_df.drop_duplicates(subset=["location", "weather"])[["location", "weather"]]
```

```
Out[43]:       location  weather
         0      Seattle  drizzle
         1      Seattle     rain
         7      Seattle      sun
         13     Seattle     snow
         192    Seattle      fog
         1461  New York     rain
         1462  New York      sun
         1470  New York  drizzle
         1473  New York     snow
         1539  New York      fog
```