Introduction to Pandas

A Library that is Used for Data Manipulation and Analysis Tool

Using Powerful Data Structures

Pandas First Steps: install and import

- Pandas is an easy package to install. Open up your terminal program (shell or cmd) and install it using either of the following commands:
- For **`jupyter notebook`** users, you can run this cell:
  - The **!** at the beginning runs cells as if they were in a terminal.
- To import pandas we usually import it with a shorter name since it's used so much:

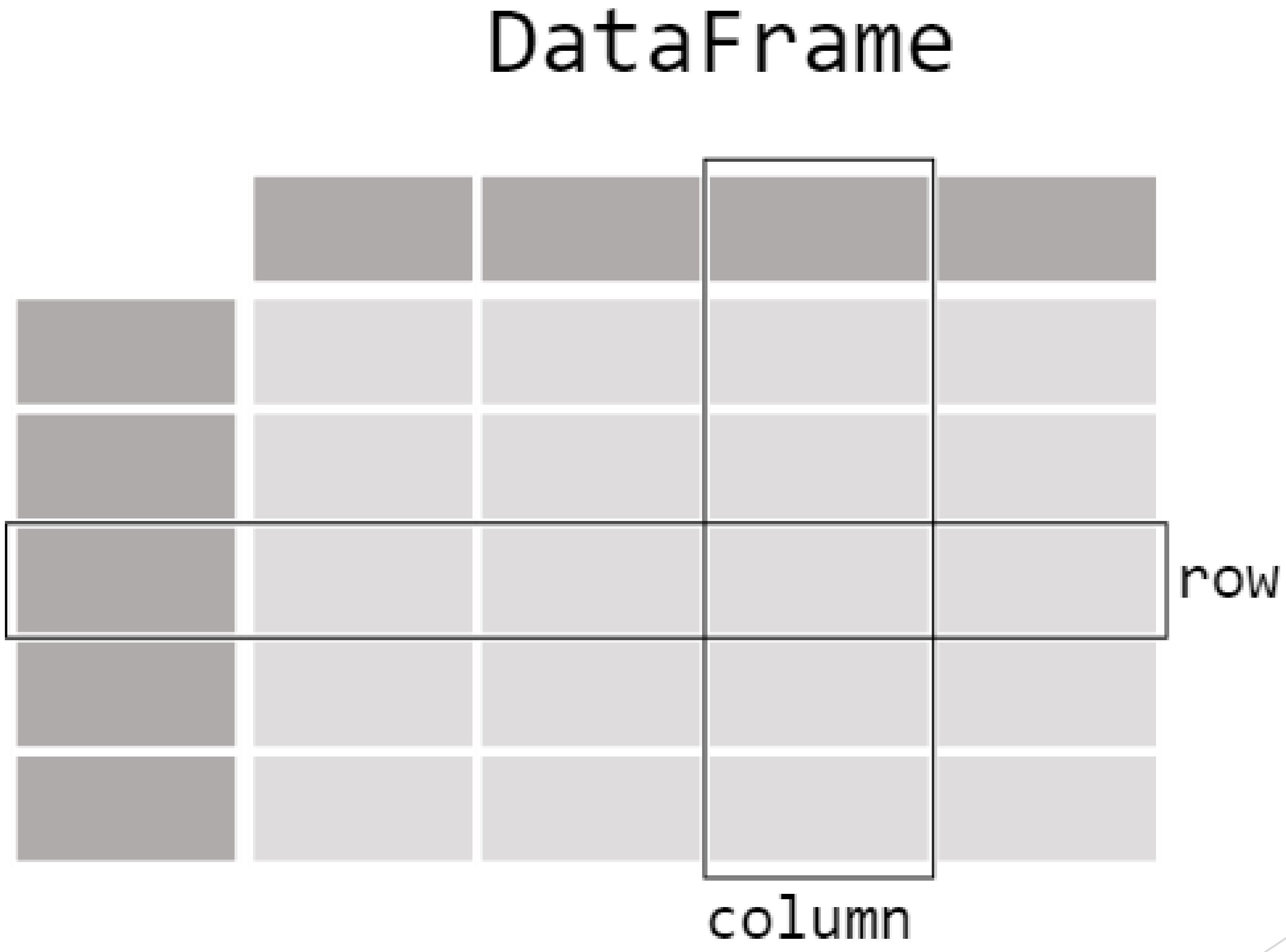
```
$ conda install pandas
OR
$ pip  install  pandas
```

```
!pip install pandas
```

```
import pandas as pd
```

Installation: https://pandas.pydata.org/pandas-docs/stable/getting_started/install.html

pandas: Data Table Representation



Core components of pandas: Series & DataFrames

- The primary two components of pandas are the Series and DataFrame.
  - Series is essentially a column, and
  - DataFrame is a multi-dimensional table made up of a collection of Series.
- DataFrames and Series are quite similar in that many operations that you can do with one you can do with the other, such as filling in null values and calculating the mean.
  - A Data frame is a two-dimensional data structure, i.e., data is aligned in a tabular fashion in rows and columns.

- **Features of DataFrame**
  - Potentially columns are of different types
  - Size – Mutable
  - Labeled axes (*rows* and *columns*)
  - Can Perform Arithmetic operations on rows and columns

Series

	apples
0	3
1	2
2	0
3	1

+

Series

	oranges
0	0
1	3
2	7
3	2

=

DataFrame

columns

	apples	oranges
0	3	0
1	2	3
2	0	7
3	1	2

rows

Types of Data Structure in Pandas

Data Structure	Dimensions	Description
Series	1	1D labeled homogeneous array with immutable size
Data Frames	2	General 2D labeled, size mutable tabular structure with potentially heterogeneously typed columns.
Panel	3	General 3D labeled, size mutable array.

- **Series & DataFrame**
  - Series is a one-dimensional array (1D Array) like structure with homogeneous data.
  - DataFrame is a two-dimensional array (2D Array) with heterogeneous data.
- **Panel**
  - Panel is a three-dimensional data structure (3D Array) with heterogeneous data.
  - It is hard to represent the panel in graphical representation.
  - But a panel can be illustrated as a container of DataFrame

pandas.DataFrame

```
pandas.DataFrame(data, index , columns , dtype , copy )
```

- **data:** data takes various forms like *ndarray*, *series*, *map*, *lists*, *dict*, constants and also another *DataFrame*.
- **index:** For the **row labels**, that are to be used for the resulting frame, Optional, Default is *np.arrange(n)* if no index is passed.
- **columns:** For **column labels**, the optional default syntax is - *np.arrange(n)*. This is only true if no index is passed.
- **dtype:** Data type of each column.
- **copy:** This command (or whatever it is) is used for copying of data, if the default is False.

- **Create DataFrame**
  - A pandas DataFrame can be created using various inputs like –
    - Lists
    - dict
    - Series
    - Numpy ndarrays
    - Another DataFrame

Creating a DataFrame from scratch

Creating a DataFrame from scratch

- There are many ways to create a DataFrame from scratch, but a great option is to just use a simple dict. But first you must import pandas.

```
import pandas as pd
```

- Let's say we have a fruit stand that sells apples and oranges. We want to have a column for each fruit and a row for each customer purchase. To organize this as a dictionary for pandas we could do something like:

```
data = { 'apples':[3, 2, 0, 1] , 'oranges':[0, 3, 7, 2] }
```

- And then pass it to the pandas DataFrame constructor:

```
df = pd.DataFrame(data)
```

	apples	oranges
0	3	0
1	2	3
2	0	7
3	1	2

How did that work?

- Each (key, value) item in data corresponds to a column in the resulting DataFrame.
- The Index of this DataFrame was given to us on creation as the numbers `0-3`, but we could also create our own when we initialize the DataFrame.
- E.g. if you want to have customer names as the index:

```
df = pd.DataFrame(data, index=['Ahmad', 'Ali', 'Rashed', 'Hamza'])
```

	apples	oranges
Ahmad	3	0
Ali	2	3
Rashed	0	7
Hamza	1	2

- So now we could locate a customer's order by using their names:

```
df.loc['Ali']
```

```
apples     2
oranges    3
Name: Ali, dtype: int64
```

pandas.DataFrame.from_dict

```
pandas.DataFrame.from_dict(data, orient='columns', dtype=None, columns=None)
```

- **data** : dict
  - Of the form `{field:array-like}` or `{field:dict}`.

- **orient** : `{'columns', 'index'}`, default `'columns'`
  - The "orientation" of the data.
  - If the keys of the passed dict should be the columns of the resulting DataFrame, pass 'columns' (default).
  - Otherwise if the keys should be rows, pass 'index'.

- **dtype** : `dtype`, default `None`
  - Data type to force, otherwise infer.

- **columns** : `list`, default `None`
  - Column labels to use when `orient='index'`. Raises a `ValueError` if used with `orient='columns'`.

https://pandas.pydata.org/pandas-docs/version/0.23/generated/pandas.DataFrame.from_dict.html

pandas' orient keyword

```
data = {'col_1':[3, 2, 1, 0], 'col_2':['a','b','c','d']}
pd.DataFrame.from_dict(data)
```

	col_1	col_2
0	3	a
1	2	b
2	1	c
3	0	d

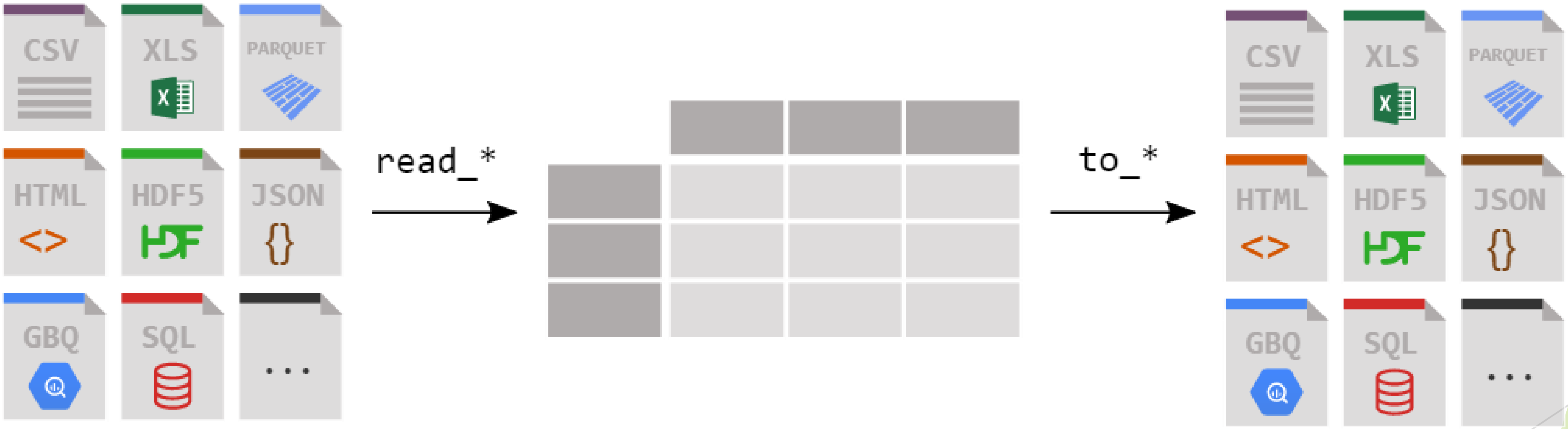
```
data = {'row_1':[3, 2, 1, 0], 'row_2':['a','b','c','d']}
pd.DataFrame.from_dict(data,
                       orient='index')
```

	0	1	2	3
row_1	3	2	1	0
row_2	a	b	c	d

```
data = {'row_1':[3, 2, 1, 0], 'row_2':['a','b','c','d']}
pd.DataFrame.from_dict(data,
                       orient  = 'index',
                       columns = ['A','B','C','D'])
```

	A	B	C	D
row_1	3	2	1	0
row_2	a	b	c	d

Loading a DataFrame from files



Reading data from a CSV file

dataset.csv - Excel

	apples	oranges
Ahmad	3	0
Ali	2	3
Rashed	0	7
Hamza	1	2

```python
import pandas as pd

df = pd.read_csv('dataset.csv')
print(df)

# OR

df = pd.read_csv('dataset.csv', index_col=0)
print(df)
```

Reading data from CSVs

- With CSV files, all you need is a single line to load in the data:

```
df = pd.read_csv('dataset.csv')
```

	Unnamed: 0	apples	oranges
0	Ahmad	3	0
1	Ali	2	3
2	Rashed	0	7
3	Hamza	1	2

- CSVs don't have indexes like our DataFrames, so all we need to do is just designate the **`index_col`** when reading:

```
df = pd.read_csv('dataset.csv', index_col=0)
```

	apples	oranges
Ahmad	3	0
Ali	2	3
Rashed	0	7
Hamza	1	2

- *Note: here we're setting the <u>index to be column zero</u>.*

Reading data from JSON

- If you have a JSON file — which is essentially a stored Python dict — pandas can read this just as easily:

```
df = pd.read_json('dataset.json')
```

- Notice this time our index came with us correctly since using JSON allowed indexes to work through nesting.
- Pandas will try to figure out how to create a DataFrame by analyzing structure of your JSON, and sometimes it doesn't get it right.
- Often you'll need to set the `orient` keyword argument depending on the structure

Example #1:Reading data from JSON

```
{
    "apples" :{"Ahmad":3,"Ali":2,"Rashed":0, "Hamza":1},
    "oranges":{"Ahmad":0,"Ali":3,"Rashed":7, "Hamza":2}
}
```

File Edit Format Run Options Window Help

```python
import pandas as pd

df = pd.read_json('dataset.json')
print(df)
```

Ln: 1 Col: 0

	apples	oranges
Ahmad	3	0
Ali	2	3
Rashed	0	7
Hamza	1	2

Example #2: Reading data from JSON

```
{
  "Ahmad"  : {"apples":3,"oranges":0},
  "Ali"    : {"apples":2,"oranges":3},
  "Rashed" : {"apples":0,"oranges":7},
  "Hamza"  : {"apples":1,"oranges":2}
}
```

File Edit Format Run Options Window Help

```python
import pandas as pd

df = pd.read_json('dataset.json')
print(df)
```

Ln: 1 Col: 0

	Ahmad	Ali	Rashed	Hamza
apples	3	2	0	1
oranges	0	3	7	2

Example #3: Reading data from JSON


```
{
  "Ahmad"  : {"apples":3,"oranges":0},
  "Ali"    : {"apples":2,"oranges":3},
  "Rashed" : {"apples":0,"oranges":7},
  "Hamza"  : {"apples":1,"oranges":2}
}
```


File Edit Format Run Options Window Help

```python
import pandas as pd

df = pd.read_json('dataset.json',
                  orient='column')
print(df)
```

Ln: 6 Col: 0

	Ahmad	Ali	Rashed	Hamza
apples	3	2	0	1
oranges	0	3	7	2

File Edit Format Run Options Window Help

```python
import pandas as pd

df = pd.read_json('dataset.json',
                  orient='index')
print(df)
```

Ln: 6 Col: 0

	apples	oranges
Ahmad	3	0
Ali	2	3
Rashed	0	7
Hamza	1	2

Converting back to a CSV or JSON

- So after extensive work on cleaning your data, you're now ready to save it as a file of your choice. Similar to the ways we read in data, pandas provides intuitive commands to save it:

```
df.to_csv('new_dataset.csv')

df.to_json('new_dataset.json')
```

- When we save JSON and CSV files, all we have to input into those functions is our desired filename with the appropriate file extension.

Reference: https://pandas.pydata.org/pandas-docs/stable/reference/api/pandas.DataFrame.to_json.html

Most important Pandas DataFrame operations

- DataFrames possess hundreds of methods and other operations that are crucial to any analysis.
- As a beginner, you should know the operations that:
  - that perform simple transformations of your data and those
  - that provide fundamental statistical analysis on your data.

Loading dataset

- We're loading this dataset from a CSV and designating the movie titles to be our index.

```
movies_df = pd.read_csv("movies.csv",
index_col="title")
```

https://grouplens.org/datasets/movielens/

Viewing your data

- The first thing to do when opening a new dataset is print out a few rows to keep as a visual reference. We accomplish this with `.head()`:

```
movies_df.head()
```

- .head() outputs the first five rows of your DataFrame by default, but we could also pass a number as well: `movies_df.head(10)` would output the top ten rows, for example.

- To see the last five rows use `.tail()` that also accepts a number, and in this case we printing the bottom two rows.:

```
movies_df.tail(2)
```

Getting info about your data

- `.info()` should be one of the very first commands you run after loading your data
- `.info()` provides the essential details about your dataset, such as the number of rows and columns, the number of non-null values, what type of data is in each column, and how much memory your DataFrame is using.

```
movies_df.info()
```

OUT:

```
<class 'pandas.core.frame.DataFrame'>
Index: 1000 entries, Guardians of the Galaxy to Nine Lives
Data columns (total 11 columns):
Rank                  1000 non-null int64
Genre                 1000 non-null object
Description           1000 non-null object
Director              1000 non-null object
Actors                1000 non-null object
Year                  1000 non-null int64
Runtime (Minutes)     1000 non-null int64
Rating                1000 non-null float64
Votes                 1000 non-null int64
Revenue (Millions)    872 non-null float64
Metascore             936 non-null float64
dtypes: float64(3), int64(4), object(4)
memory usage: 93.8+ KB
```

```
movies_df.shape
```

OUT:

```
(1000, 11)
```

Handling duplicates

- This dataset does not have duplicate rows, but it is always important to verify you aren't aggregating duplicate rows.
- To demonstrate, let's simply just double up our movies DataFrame by appending it to itself:
- Using `append()` will return a copy without affecting the original DataFrame. We are capturing this copy in **temp** so we aren't working with the real data.
- Notice call `.shape` quickly proves our DataFrame rows have doubled.

```
temp_df = movies_df.append(movies_df)
temp_df.shape
```

OUT:

```
(2000, 11)
```

Now we can try dropping duplicates:

```
temp_df = temp_df.drop_duplicates()
temp_df.shape
```

OUT:

```
(1000, 11)
```

Handling duplicates

- Just like **`append()`**, the **`drop_duplicates()`** method will also return a copy of your DataFrame, but this time with duplicates removed. Calling **`.shape`** confirms we're back to the 1000 rows of our original dataset.
- It's a little verbose to keep assigning DataFrames to the same variable like in this example. For this reason, pandas has the inplace keyword argument on many of its methods. Using **`inplace=True`** will modify the DataFrame object in place:

```
temp_df.drop_duplicates(inplace=True)
```

- Another important argument for **`drop_duplicates()`** is keep, which has three possible options:
  - first: (default) Drop duplicates except for the first occurrence.
  - last: Drop duplicates except for the last occurrence.
  - False: Drop all duplicates.

https://www.learndatasci.com/tutorials/python-pandas-tutorial-complete-introduction-for-beginners/

Understanding your variables

- Using `.describe()` on an entire DataFrame we can get a summary of the distribution of continuous variables:

```
movies_df.describe()
```

OUT:

	rank	year	runtime	rating	
count	1000.000000	1000.000000	1000.000000	1000.000000	1.00
mean	500.500000	2012.783000	113.172000	6.723200	1.69
std	288.819436	3.205962	18.810908	0.945429	1.88
min	1.000000	2006.000000	66.000000	1.900000	6.10
25%	250.750000	2010.000000	100.000000	6.200000	3.6
50%	500.500000	2014.000000	111.000000	6.800000	1.10
75%	750.250000	2016.000000	123.000000	7.400000	2.3
max	1000.000000	2016.000000	191.000000	9.000000	1.79

- `.describe()` can also be used on a categorical variable to get the count of rows, unique count of categories, top category, and freq of top category:

```
movies_df['genre'].describe()
```

OUT:

```
count                        1000
unique                        207
top         Action,Adventure,Sci-Fi
freq                           50
Name: genre, dtype: object
```

- This tells us that the genre column has 207 unique values, the top value is Action/Adventure/Sci-Fi, which shows up 50 times (freq).

More Examples

```python
import pandas as pd
data = [1,2,3,10,20,30]
df = pd.DataFrame(data)
print(df)
```

```
    0
0   1
1   2
2   3
3  10
4  20
5  30
```

```python
import pandas as pd
data = {'Name' : ['AA', 'BB'], 'Age': [30,45]}
df = pd.DataFrame(data)
print(df)
```

```
  Name  Age
0   AA   30
1   BB   45
```

More Examples

```python
import pandas as pd
data = [{'a': 1, 'b': 2},{'a': 5, 'b': 10, 'c': 20}]
df = pd.DataFrame(data)
print(df)
```

```
   a   b     c
0  1   2   NaN
1  5  10  20.0
```

```python
import pandas as pd
data = [{'a': 1, 'b': 2},{'a': 5, 'b': 10, 'c': 20}]
df = pd.DataFrame(data, index=['first', 'second'])
print(df)
```

```
        a   b     c
first   1   2   NaN
second  5  10  20.0
```

More Examples

E.g. This shows how to create a DataFrame with a list of dictionaries, row indices, and column indices.

```
import pandas as pd
data = [{'a': 1, 'b': 2},{'a': 5, 'b': 10, 'c': 20}]

#With two column indices, values same as dictionary keys
df1 = pd.DataFrame(data,index=['first','second'],columns=['a','b'])

#With two column indices with one index with other name
df2 = pd.DataFrame(data,index=['first','second'],columns=['a','b1'])

print(df1)
print('...........')
print(df2)
```

```
        a   b
first   1   2
second  5  10
...........
        a  b1
first   1 NaN
second  5 NaN
```

More Examples:
Create a DataFrame from Dict of Series

```
import pandas as pd
d = {'one' : pd.Series([1, 2, 3]   , index=['a', 'b', 'c']),
      'two' : pd.Series([1,2, 3, 4], index=['a', 'b', 'c', 'd'])
     }
df = pd.DataFrame(d)
print(df)
```

```
   one  two
a  1.0    1
b  2.0    2
c  3.0    3
d  NaN    4
```

More Examples: Column Addition

```
import pandas as pd
d = {'one':pd.Series([1,2,3],   index=['a','b','c']),
     'two':pd.Series([1,2,3,4], index=['a','b','c','d'])
    }
df = pd.DataFrame(d)
# Adding a new column to an existing DataFrame object
# with column label by passing new series

print("Adding a new column by passing as Series:")
df['three'] = pd.Series([10,20,30],index=['a','b','c'])
print(df)

print("Adding a column using an existing columns in
DataFrame:")
df['four'] = df['one']+df['three']
print(df)
```

```
Adding a column using Series:

   one  two  three
a  1.0    1   10.0
b  2.0    2   20.0
c  3.0    3   30.0
d  NaN    4    NaN


Adding a column using columns:

   one  two  three  four
a  1.0    1   10.0  11.0
b  2.0    2   20.0  22.0
c  3.0    3   30.0  33.0
d  NaN    4    NaN   NaN
```

More Examples: Column Deletion

```python
# Using the previous DataFrame, we will delete a column
# using del function
import pandas as pd
d = {'one'   : pd.Series([1, 2, 3],    index=['a', 'b', 'c']),
     'two'   : pd.Series([1, 2, 3, 4], index=['a', 'b', 'c', 'd']),
     'three' : pd.Series([10,20,30],   index=['a','b','c'])
    }
df = pd.DataFrame(d)
print ("Our dataframe is:")
print(df)

# using del function
print("Deleting the first column using DEL function:")
del df['one']
print(df)

# using pop function
print("Deleting another column using POP function:")
df.pop('two')
print(df)
```

```
Our dataframe is:
   one  two  three
a  1.0    1   10.0
b  2.0    2   20.0
c  3.0    3   30.0
d  NaN    4    NaN

Deleting the first column:
   two  three
a    1   10.0
b    2   20.0
c    3   30.0
d    4    NaN

Deleting another column:
a   10.0
b   20.0
c   30.0
d    NaN
```

More Examples: Slicing in DataFrames

```
import pandas as pd
d = {'one' : pd.Series([1, 2, 3],    index=['a', 'b', 'c']),
     'two' : pd.Series([1, 2, 3, 4], index=['a', 'b', 'c','d'])
    }
df = pd.DataFrame(d)
print(df[2:4])
```

	one	two
c	3.0	3
d	NaN	4

More Examples: Addition of rows

```
import pandas as pd
d = {'one' : pd.Series([1, 2, 3],    index=['a', 'b', 'c']),
     'two' : pd.Series([1, 2, 3, 4], index=['a', 'b', 'c','d'])
    }
df = pd.DataFrame(d)
print(df)

df2 = pd.DataFrame([[5,6], [7,8]], columns = ['a', 'b'])
df = df.append(df2 )
print(df)
```

```
   one  two
a  1.0    1
b  2.0    2
c  3.0    3
d  NaN    4


   one  two    a    b
a  1.0  1.0  NaN  NaN
b  2.0  2.0  NaN  NaN
c  3.0  3.0  NaN  NaN
d  NaN  4.0  NaN  NaN
0  NaN  NaN  5.0  6.0
1  NaN  NaN  7.0  8.0
```

More Examples: Deletion of rows

```
import pandas as pd
d = {'one':pd.Series([1, 2, 3],    index=['a','b','c']),
     'two':pd.Series([1, 2, 3, 4], index=['a','b','c','d'])
    }
df = pd.DataFrame(d)
print(df)

df2 = pd.DataFrame([[5,6], [7,8]], columns = ['a', 'b'])
df = df.append(df2 )
print(df)

df = df.drop(0)
print(df)
```

```
   one  two
a  1.0    1
b  2.0    2
c  3.0    3
d  NaN    4

   one  two    a    b
a  1.0  1.0  NaN  NaN
b  2.0  2.0  NaN  NaN
c  3.0  3.0  NaN  NaN
d  NaN  4.0  NaN  NaN
0  NaN  NaN  5.0  6.0
1  NaN  NaN  7.0  8.0

   one  two    a    b
a  1.0  1.0  NaN  NaN
b  2.0  2.0  NaN  NaN
c  3.0  3.0  NaN  NaN
d  NaN  4.0  NaN  NaN
1  NaN  NaN  7.0  8.0
```

More Examples: Reindexing

```python
import pandas as pd
# Creating the first dataframe
df1 = pd.DataFrame({"A":[1, 5, 3, 4, 2],
            "B":[3, 2, 4, 3, 4],
            "C":[2, 2, 7, 3, 4],
            "D":[4, 3, 6, 12, 7]},
            index =["A1", "A2", "A3", "A4", "A5"])

# Creating the second dataframe
df2 = pd.DataFrame({"A":[10, 11, 7, 8, 5],
            "B":[21, 5, 32, 4, 6],
            "C":[11, 21, 23, 7, 9],
            "D":[1, 5, 3, 8, 6]},
            index =["A1", "A3", "A4", "A7", "A8"])

# Print the first dataframe
print(df1)
print(df2)
# find matching indexes
df1.reindex_like(df2)
```

- Pandas **dataframe.reindex_like()** function return an object with matching indices to myself.
- Any non-matching indexes are filled with NaN values.

Out[72]:

	A	B	C	D
A1	1.0	3.0	2.0	4.0
A3	3.0	4.0	7.0	6.0
A4	4.0	3.0	3.0	12.0
A7	NaN	NaN	NaN	NaN
A8	NaN	NaN	NaN	NaN

More Examples: Concatenating Objects (Data Frames)

```
import pandas as pd
df1 = pd.DataFrame({'Name':['A','B'], 'SSN':[10,20], 'marks':[90, 95] })
df2 = pd.DataFrame({'Name':['B','C'], 'SSN':[25,30], 'marks':[80, 97] })
df3 = pd.concat([df1, df2])
df3
```

Handling categorical data

- There are many data that are repetitive for example gender , country , and codes are always repetitive .
- Categorical variables can take on only a limited
- The categorical data type is useful in the following cases −
- A string variable consisting of only a few different values. Converting such a string variable to a categorical variable will save some memory.
- The lexical order of a variable is not the same as the logical order (“one”, “two”, “three”).
  - By converting to a categorical and specifying an order on the categories, sorting and min/max will use the logical order instead of the lexical order.
- As a signal to other python libraries that this column should be treated as a categorical variable (e.g. to use suitable statistical methods or plot types).

Examples

```
import pandas as pd
cat = pd.Categorical(['a', 'b', 'c', 'a', 'b', 'c'])
print(cat)
```

```
import pandas as pd
import numpy as np
cat = pd.Categorical(["a", "c", "c", np.nan], categories=["b", "a", "c"])
df = pd.DataFrame({"cat": cat, "s":["a", "c", "c", np.nan]})
print(df.describe())
print(df["cat"].describe())
```

Reading data from a SQL database

- f you’re working with data from a SQL database you need to first establish a connection using an appropriate Python library, then pass a query to pandas. Here we'll use SQLite to demonstrate.
- First, we need pysqlite3 installed, so run this command in your terminal:
  - pip install pysqlite3
  - Or run this cell if you're in a notebook: !pip install pysqlite3
- sqlite3 is used to create a connection to a database which we can then use to generate a DataFrame through a SELECT query.
  - So first we'll make a connection to a SQLite database file:

```
import sqlite3
con = sqlite3.connect("database.db")
```

  - In this SQLite database we have a table called purchases, and our index is in a column called "index".
  - By passing a SELECT query and our con, we can read from the purchases table:

```
df = pd.read_sql_query("SELECT * FROM purchases", con)
```

Reading data from a SQL database

- In this SQLite database we have a table called purchases, and our index is in a column called "index".
- By passing a SELECT query and our con, we can read from the purchases table:

```
df = pd.read_sql_query("SELECT * FROM purchases", con)
```

OUT:

	index	apples	oranges
0	June	3	0
1	Robert	2	3
2	Lily	0	7
3	David	1	2

- Just like with CSVs, we could pass index_col='index', but we can also set an index after-the-fact:
  - In fact, we could use set_index() on any DataFrame using any column at any time. Indexing Series and DataFrames is a very common task, and the different ways of doing it is worth remembering.

```
df = df.set_index('index')
```

OUT:

	apples	oranges
index		
June	3	0
Robert	2	3
Lily	0	7
David	1	2

References

pandas documentation

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

- pandas: Input/output
  - https://pandas.pydata.org/pandas-docs/stable/reference/io.html
- pandas: DataFrame
  - https://pandas.pydata.org/pandas-docs/stable/reference/frame.html
- pandas: Series
  - https://pandas.pydata.org/pandas-docs/stable/reference/series.html
- pandas: Plotting
  - https://pandas.pydata.org/pandas-docs/stable/reference/plotting.html

Python For Data Science *Cheat Sheet*

Pandas Basics

Learn Python for Data Science Interactively at www.DataCamp.com

Pandas

The Pandas library is built on NumPy and provides easy-to-use data structures and data analysis tools for the Python programming language.

Use the following import convention:

```
>>> import pandas as pd
```

Pandas Data Structures

Series

A one-dimensional labeled array capable of holding any data type

Index

A	3
B	-5
C	7
D	4

```
>>> s = pd.Series([3, -5, 7, 4], index=['a', 'b', 'c', 'd'])
```

DataFrame

Columns

Index

	Country	Capital	Population
1	Belgium	Brussels	11190846
2	India	New Delhi	1303171035
3	Brazil	Brasília	207847528

A two-dimensional labeled data structure with columns of potentially different types

```
>>> data = {'Country': ['Belgium', 'India', 'Brazil'],
            'Capital': ['Brussels', 'New Delhi', 'Brasília'],
            'Population': [11190846, 1303171035, 207847528]}

>>> df = pd.DataFrame(data,
                      columns=['Country', 'Capital', 'Population'])
```

Asking For Help

```
>>> help(pd.Series.loc)
```

Selection

Also see NumPy Arrays

Getting

```
>>> s['b']                        Get one element
  -5
>>> df[1:]                        Get subset of a DataFrame
   Country    Capital    Population
 1  India    New Delhi   1303171035
 2  Brazil   Brasília    207847528
```

Selecting, Boolean Indexing & Setting

By Position

```
>>> df.iloc([0],[0])              Select single value by row &
 'Belgium'                        column
>>> df.iat([0],[0])
 'Belgium'
```

By Label

```
>>> df.loc([0], ['Country'])      Select single value by row &
 'Belgium'                        column labels
>>> df.at([0], ['Country'])
 'Belgium'
```

By Label/Position

```
>>> df.ix[2]                      Select single row of
 Country       Brazil             subset of rows
 Capital     Brasília
 Population  207847528
>>> df.ix[:,'Capital']            Select a single column of
 0     Brussels                   subset of columns
 1    New Delhi
 2     Brasília
>>> df.ix[1,'Capital']            Select rows and columns
 'New Delhi'
```

Boolean Indexing

```
>>> s[~(s > 1)]                   Series s where value is not >1
>>> s[(s < -1) | (s > 2)]         s where value is <-1 or >2
>>> df[df['Population']>1200000000]   Use filter to adjust DataFrame
```

Setting

```
>>> s['a'] = 6                    Set index a of Series s to 6
```

I/O

Read and Write to CSV

```
>>> pd.read_csv('file.csv', header=None, nrows=5)
>>> pd.to_csv('myDataFrame.csv')
```

Read and Write to Excel

```
>>> pd.read_excel('file.xlsx')
>>> pd.to_excel('dir/myDataFrame.xlsx', sheet_name='Sheet1')
```

Read multiple sheets from the same file

```
>>> xlsx = pd.ExcelFile('file.xls')
>>> df = pd.read_excel(xlsx, 'Sheet1')
```

Read and Write to SQL Query or Database Table

```
>>> from sqlalchemy import create_engine
>>> engine = create_engine('sqlite:///:memory:')
>>> pd.read_sql("SELECT * FROM my_table;", engine)
>>> pd.read_sql_table('my_table', engine)
>>> pd.read_sql_query("SELECT * FROM my_table;", engine)
```

`read_sql()` is a convenience wrapper around `read_sql_table()` and `read_sql_query()`

```
>>> pd.to_sql('myDf', engine)
```

Dropping

```
>>> s.drop(['a', 'c'])            Drop values from rows (axis=0)
>>> df.drop('Country', axis=1)    Drop values from columns(axis=1)
```

Sort & Rank

```
>>> df.sort_index()               Sort by labels along an axis
>>> df.sort_values(by='Country')  Sort by the values along an axis
>>> df.rank()                     Assign ranks to entries
```

Retrieving Series/DataFrame Information

Basic Information

```
>>> df.shape                      (rows,columns)
>>> df.index                      Describe index
>>> df.columns                    Describe DataFrame columns
>>> df.info()                     Info on DataFrame
>>> df.count()                    Number of non-NA values
```

Summary

```
>>> df.sum()                      Sum of values
>>> df.cumsum()                   Cummulative sum of values
>>> df.min()/df.max()             Minimum/maximum values
>>> df.idxmin()/df.idxmax()       Minimum/Maximum index value
>>> df.describe()                 Summary statistics
>>> df.mean()                     Mean of values
>>> df.median()                   Median of values
```

Applying Functions

```
>>> f = lambda x: x*2
>>> df.apply(f)                   Apply function
>>> df.applymap(f)                Apply function element-wise
```

Data Alignment

Internal Data Alignment

NA values are introduced in the indices that don't overlap:

```
>>> s3 = pd.Series([7, -2, 3], index=['a', 'c', 'd'])
>>> s + s3
 a    10.0
 b     NaN
 c     5.0
 d     7.0
```

Arithmetic Operations with Fill Methods

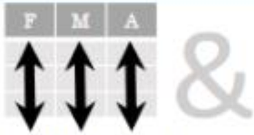
You can also do the internal data alignment yourself with the help of the fill methods:

```
>>> s.add(s3, fill_value=0)
 a    10.0
 b    -5.0
 c     5.0
 d     7.0
>>> s.sub(s3, fill_value=2)
>>> s.div(s3, fill_value=4)
>>> s.mul(s3, fill_value=3)
```

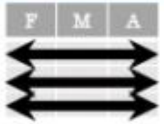
Data Wrangling
with pandas
Cheat Sheet
http://pandas.pydata.org

Tidy Data – A foundation for wrangling in pandas

In a tidy data set:



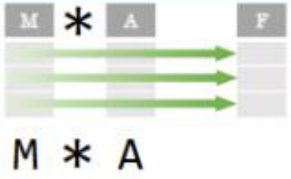
&



Each **variable** is saved in its own **column**

Each **observation** is saved in its own **row**

Tidy data complements pandas's vectorized operations. pandas will automatically preserve observations as you manipulate variables. No other format works as intuitively with pandas.



Syntax – Creating DataFrames

	a	b	c
1	4	7	10
2	5	8	11
3	6	9	12

```
df = pd.DataFrame(
        {"a" : [4 ,5, 6],
         "b" : [7, 8, 9],
         "c" : [10, 11, 12]},
      index = [1, 2, 3])
```

Specify values for each column.

```
df = pd.DataFrame(
     [[4, 7, 10],
      [5, 8, 11],
      [6, 9, 12]],
     index=[1, 2, 3],
     columns=['a', 'b', 'c'])
```

Specify values for each row.

		a	b	c
n	v			
d	1	4	7	10
	2	5	8	11
e	2	6	9	12

```
df = pd.DataFrame(
        {"a" : [4 ,5, 6],
         "b" : [7, 8, 9],
         "c" : [10, 11, 12]},
index = pd.MultiIndex.from_tuples(
        [('d',1),('d',2),('e',2)],
          names=['n','v']))
```

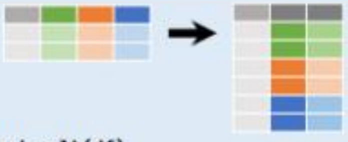
Create DataFrame with a MultiIndex

Method Chaining

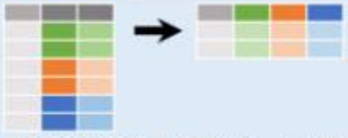
Most pandas methods return a DataFrame so that another pandas method can be applied to the result. This improves readability of code.

```
df = (pd.melt(df)
      .rename(columns={
              'variable' : 'var',
              'value' : 'val'})
      .query('val >= 200')
     )
```

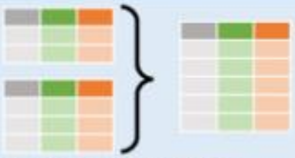
Reshaping Data – Change the layout of a data set



`pd.melt(df)`
Gather columns into rows.



`df.pivot(columns='var', values='val')`
Spread rows into columns.



`pd.concat([df1,df2])`
Append rows of DataFrames

`pd.concat([df1,df2], axis=1)`
Append columns of DataFrames

`df.sort_values('mpg')`
Order rows by values of a column (low to high).

`df.sort_values('mpg',ascending=False)`
Order rows by values of a column (high to low).

`df.rename(columns = {'y':'year'})`
Rename the columns of a DataFrame

`df.sort_index()`
Sort the index of a DataFrame

`df.reset_index()`
Reset index of DataFrame to row numbers, moving index to columns.

`df.drop(columns=['Length','Height'])`
Drop columns from DataFrame

Subset Observations (Rows)

`df[df.Length > 7]`
Extract rows that meet logical criteria.

`df.drop_duplicates()`
Remove duplicate rows (only considers columns).

`df.head(n)`
Select first n rows.

`df.tail(n)`
Select last n rows.

`df.sample(frac=0.5)`
Randomly select fraction of rows.

`df.sample(n=10)`
Randomly select n rows.

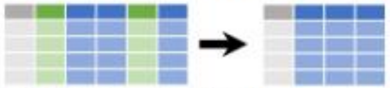
`df.iloc[10:20]`
Select rows by position.

`df.nlargest(n, 'value')`
Select and order top n entries.

`df.nsmallest(n, 'value')`
Select and order bottom n entries.

Logic in Python (and pandas)			
<	Less than	!=	Not equal to
>	Greater than	`df.column.isin(values)`	Group membership
==	Equals	`pd.isnull(obj)`	Is NaN
<=	Less than or equals	`pd.notnull(obj)`	Is not NaN
>=	Greater than or equals	`&,|,~,^,df.any(),df.all()`	Logical and, or, not, xor, any, all

Subset Variables (Columns)



`df[['width','length','species']]`
Select multiple columns with specific names.

`df['width']` *or* `df.width`
Select single column with specific name.

`df.filter(regex='regex')`
Select columns whose name matches regular expression *regex*.

regex (Regular Expressions) Examples	
`'\.'`	Matches strings containing a period '.'
`'Length$'`	Matches strings ending with word 'Length'
`'^Sepal'`	Matches strings beginning with the word 'Sepal'
`'^x[1-5]$'`	Matches strings beginning with 'x' and ending with 1,2,3,4,5
`'^(?!Species$).*'`	Matches strings except the string 'Species'

`df.loc[:,'x2':'x4']`
Select all columns between x2 and x4 (inclusive).

`df.iloc[:,[1,2,5]]`
Select columns in positions 1, 2 and 5 (first column is 0).

`df.loc[df['a'] > 10, ['a','c']]`
Select rows meeting logical condition, and only the specific columns .

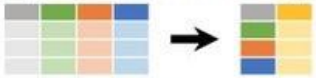
Summarize Data

`df['Length'].value_counts()`
Count number of rows with each unique value of variable

`len(df)`
# of rows in DataFrame.

`len(df['w'].unique())`
# of distinct values in a column.

`df.describe()`
Basic descriptive statistics for each column (or GroupBy)



pandas provides a large set of **summary functions** that operate on different kinds of pandas objects (DataFrame columns, Series, GroupBy, Expanding and Rolling (see below)) and produce single values for each of the groups. When applied to a DataFrame, the result is returned as a pandas Series for each column. Examples:

`sum()`
Sum values of each object.

`count()`
Count non-NA/null values of each object.

`median()`
Median value of each object.

`quantile([0.25,0.75])`
Quantiles of each object.

`apply(function)`
Apply function to each object.

`min()`
Minimum value in each object.

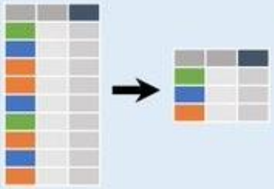
`max()`
Maximum value in each object.

`mean()`
Mean value of each object.

`var()`
Variance of each object.

`std()`
Standard deviation of each object.

Group Data



`df.groupby(by="col")`
Return a GroupBy object, grouped by values in column named "col".

`df.groupby(level="ind")`
Return a GroupBy object, grouped by values in index level named "ind".

All of the summary functions listed above can be applied to a group. Additional GroupBy functions:

`size()`
Size of each group.

`agg(function)`
Aggregate group using function.

Windows

`df.expanding()`
Return an Expanding object allowing summary functions to be applied cumulatively.

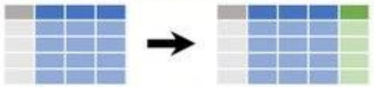
`df.rolling(n)`
Return a Rolling object allowing summary functions to be applied to windows of length n.

Handling Missing Data

`df=df.dropna()`
Drop rows with any column having NA/null data.

`df=df.fillna(value)`
Replace all NA/null data with value.

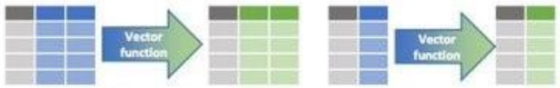
Make New Variables



`df=df.assign(Area=lambda df: df.Length*df.Height)`
Compute and append one or more new columns.

`df['Volume'] = df.Length*df.Height*df.Depth`
Add single column.

`pd.qcut(df.col, n, labels=False)`
Bin column into n buckets.



pandas provides a large set of **vector functions** that operate on all columns of a DataFrame or a single selected column (a pandas Series). These functions produce vectors of values for each of the columns, or a single Series for the individual Series. Examples:

`max(axis=1)`
Element-wise max.

`clip(lower=-10,upper=10)`
Trim values at input thresholds

`min(axis=1)`
Element-wise min.

`abs()`
Absolute value.

The examples below can also be applied to groups. In this case, the function is applied on a per-group basis, and the returned vectors are of the length of the original DataFrame.

`shift(1)`
Copy with values shifted by 1.

`rank(method='dense')`
Ranks with no gaps.

`rank(method='min')`
Ranks. Ties get min rank.

`rank(pct=True)`
Ranks rescaled to interval [0, 1].

`rank(method='first')`
Ranks. Ties go to first value.

`shift(-1)`
Copy with values lagged by 1.

`cumsum()`
Cumulative sum.

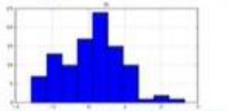
`cummax()`
Cumulative max.

`cummin()`
Cumulative min.

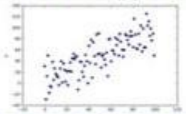
`cumprod()`
Cumulative product.

Plotting

`df.plot.hist()`
Histogram for each column



`df.plot.scatter(x='w',y='h')`
Scatter chart using pairs of points



Combine Data Sets

adf

x1	x2
A	1
B	2
C	3

+

bdf

x1	x3
A	T
B	F
D	T

=

Standard Joins

x1	x2	x3
A	1	T
B	2	F
C	3	NaN

```
pd.merge(adf, bdf,
         how='left', on='x1')
```
Join matching rows from bdf to adf.

x1	x2	x3
A	1.0	T
B	2.0	F
D	NaN	T

```
pd.merge(adf, bdf,
         how='right', on='x1')
```
Join matching rows from adf to bdf.

x1	x2	x3
A	1	T
B	2	F

```
pd.merge(adf, bdf,
         how='inner', on='x1')
```
Join data. Retain only rows in both sets.

x1	x2	x3
A	1	T
B	2	F
C	3	NaN
D	NaN	T

```
pd.merge(adf, bdf,
         how='outer', on='x1')
```
Join data. Retain all values, all rows.

Filtering Joins

x1	x2
A	1
B	2

`adf[adf.x1.isin(bdf.x1)]`
All rows in adf that have a match in bdf.

x1	x2
C	3

`adf[~adf.x1.isin(bdf.x1)]`
All rows in adf that do not have a match in bdf.

ydf

x1	x2
A	1
B	2
C	3

+

zdf

x1	x2
B	2
C	3
D	4

=

Set-like Operations

x1	x2
B	2
C	3

`pd.merge(ydf, zdf)`
Rows that appear in both ydf and zdf (Intersection).

x1	x2
A	1
B	2
C	3
D	4

`pd.merge(ydf, zdf, how='outer')`
Rows that appear in either or both ydf and zdf (Union).

x1	x2
A	1

```
pd.merge(ydf, zdf, how='outer',
         indicator=True)
.query('_merge == "left_only"')
.drop(['_merge'],axis=1)
```
Rows that appear in ydf but not zdf (Setdiff).

matplotlib Cheat sheet

Version 3.5.0

Quick start

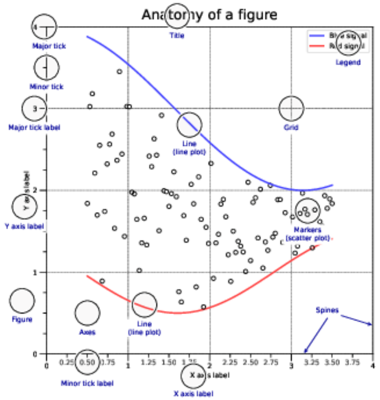
```
import numpy as np
import matplotlib as mpl
import matplotlib.pyplot as plt

X = np.linspace(0, 2*np.pi, 100)
Y = np.cos(X)

fig, ax = plt.subplots()
ax.plot(X, Y, color='green')

fig.savefig("figure.pdf")
plt.show()
```

Anatomy of a figure



Subplots layout

```
subplot[s](rows,cols,…)
fig, axs = plt.subplots(3, 3)

G = gridspec(rows,cols,…)
ax = G[0,:]

ax.inset_axes(extent)

d=make_axes_locatable(ax)
ax = d.new_horizontal('10%')
```

Getting help

- matplotlib.org
- github.com/matplotlib/matplotlib/issues
- discourse.matplotlib.org
- stackoverflow.com/questions/tagged/matplotlib
- https://gitter.im/matplotlib/matplotlib
- twitter.com/matplotlib
- Matplotlib users mailing list

Basic plots

- `plot([X],Y,[fmt],…)` — X, Y, fmt, color, marker, linestyle
- `scatter(X,Y,…)` — X, Y, [s]izes, [c]olors, marker, cmap
- `bar[h](x,height,…)` — x, height, width, bottom, align, color
- `imshow(Z,…)` — Z, cmap, interpolation, extent, origin
- `contour[f]([X],[Y],Z,…)` — X, Y, Z, levels, colors, extent, origin
- `pcolormesh([X],[Y],Z,…)` — X, Y, Z, vmin, vmax, cmap
- `quiver([X],[Y],U,V,…)` — X, Y, U, V, C, units, angles
- `pie(X,…)` — Z, explode, labels, colors, radius
- `text(x,y,text,…)` — x, y, text, va, ha, size, weight, transform
- `fill[_between][x](…)` — X, Y1, Y2, color, where

Advanced plots

- `step(X,Y,[fmt],…)` — X, Y, fmt, color, marker, where
- `boxplot(X,…)` — X, notch, sym, bootstrap, widths
- `errorbar(X,Y,xerr,yerr,…)` — X, Y, xerr, yerr, fmt
- `hist(X, bins, …)` — X, bins, range, density, weights
- `violinplot(D,…)` — D, positions, widths, vert
- `barbs([X],[Y], U, V, …)` — X, Y, U, V, C, length, pivot, sizes
- `eventplot(positions,…)` — positions, orientation, lineoffsets
- `hexbin(X,Y,C,…)` — X, Y, C, gridsize, bins

Scales

`ax.set_[xy]scale(scale,…)`

- linear — any values
- log — values > 0
- symlog — any values
- logit — 0 < values < 1

Projections

`subplot(…,projection=p)`

- p='polar'
- p='3d'
- p=ccrs.Orthographic() — import cartopy.crs as ccrs

Lines

linestyle or ls: "-" ":" "--" "-." (0,(0.01,2))

capstyle or dash_capstyle: "butt" "round" "projecting"

Markers

'.' 'o' 's' 'P' 'X' '*' 'p' 'D' '<' '>' '^' 'v'

'1' '2' '3' '4' '+' 'x' '|' '_' 4 5 6 7

'$♠$' '$♣$' '$♥$' '$♦$' '$→$' '$←$' '$↑$' '$↓$' '$◐$' '$◑$' '$◒$' '$◓$'

markevery: 10, [0, -1], (25, 5), [0, 25, -1]

Colors

'Cn', 'x', 'name', (R,G,B[,A]), '#RRGGBB[AA]', 'x.y'

C0 C1 C2 C3 C4 C5 C6 C7 C8 C9

b g r c m y k w

DarkRed Firebrick Crimson IndianRed Salmon

(1,0,0) (1,0,0,0.75) (1,0,0,0.5) (1,0,0,0.25)

#FF0000 #FF0000BB #FF000088 #FF000044

0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0

Colormaps

`plt.get_cmap(name)`

- Uniform: viridis, magma, plasma
- Sequential: Greys, YlOrBr, Wistia
- Diverging: Spectral, coolwarm, RdGy
- Qualitative: tab10, tab20
- Cyclic: twilight

Tick locators

```
from matplotlib import ticker
ax.[xy]axis.set_[minor|major]_locator(locator)
```

- ticker.NullLocator()
- ticker.MultipleLocator(0.5)
- ticker.FixedLocator([0, 1, 5])
- ticker.LinearLocator(numticks=3)
- ticker.IndexLocator(base=0.5, offset=0.25)
- ticker.AutoLocator()
- ticker.MaxNLocator(n=4)
- ticker.LogLocator(base=10, numticks=15)

Tick formatters

```
from matplotlib import ticker
ax.[xy]axis.set_[minor|major]_formatter(formatter)
```

- ticker.NullFormatter()
- ticker.FixedFormatter(['zero', 'one', 'two', …])
- ticker.FuncFormatter(lambda x, pos: "[%.2f]" % x)
- ticker.FormatStrFormatter('>%d<')
- ticker.ScalarFormatter()
- ticker.StrMethodFormatter('{x}')
- ticker.PercentFormatter(xmax=5)

Ornaments

`ax.legend(…)` — handles, labels, loc, title, frameon

`ax.colorbar(…)` — mappable, ax, cax, orientation

`ax.annotate(…)` — text, xy, xytext, xycoords, textcoords, arrowprops

Event handling

```
fig, ax = plt.subplots()
def on_click(event):
    print(event)
fig.canvas.mpl_connect(
    'button_press_event', on_click)
```

Animation

```
import matplotlib.animation as mpla

T = np.linspace(0, 2*np.pi, 100)
S = np.sin(T)
line, = plt.plot(T, S)
def animate(i):
    line.set_ydata(np.sin(T+i/50))
anim = mpla.FuncAnimation(
    plt.gcf(), animate, interval=5)
plt.show()
```

Styles

`plt.style.use(style)`

default, classic, grayscale, ggplot, seaborn, fast, bmh, Solarize_Light2, seaborn-notebook

Quick reminder

```
ax.grid()
ax.set_[xy]lim(vmin, vmax)
ax.set_[xy]label(label)
ax.set_[xy]ticks(ticks, [labels])
ax.set_[xy]ticklabels(labels)
ax.set_title(title)
ax.tick_params(width=10, …)
ax.set_axis_[on|off]()

fig.suptitle(title)
fig.tight_layout()
plt.gcf(), plt.gca()
mpl.rc('axes', linewidth=1, …)
[fig|ax].patch.set_alpha(0)
text=r'$\frac{-e^{i\pi}}{2^n}$'
```

Keyboard shortcuts

ctrl + s	Save	ctrl + w	Close plot
r	Reset view	f	Fullscreen 0/1
f	View forward	b	View back
p	Pan view	o	Zoom to rect
x	X pan/zoom	y	Y pan/zoom
g	Minor grid 0/1	G	Major grid 0/1
l	X axis log/linear	L	Y axis log/linear

Ten simple rules

1. Know your audience
2. Identify your message
3. Adapt the figure
4. Captions are not optional
5. Do not trust the defaults
6. Use color effectively
7. Do not mislead the reader
8. Avoid "chartjunk"
9. Message trumps beauty
10. Get the right tool