



3030&7130ICT  
Data Analytics

## **Lab 01 – Data Processing with Python**

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## I. General information

All of your workshops and assignment need to be submitted to GitHub. Create a Github



repository and fill the form <https://forms.office.com/r/Yb6BtX0KYC>

## II. Data Input and Output

This notebook is the reference code for getting input and output, pandas can read a variety of file types using its pd.read\_csv methods. Let's take a look at the most common data types:

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

### 1. CSV

#### CSV Input

```
In [25]: df = pd.read_csv('example.csv')
```

```
Out[25]:
```

	a	b	c	d
0	0	1	2	3
1	4	5	6	7
2	8	9	10	11
3	12	13	14	15

## CSV Output

```
In [24]: df.to_csv('example.csv', index=False)
```

## 2. Excel

Pandas can read and write excel files, keep in mind, this only imports data. Not formulas or images, having images or macros may cause this `read_excel` method to crash.

### Excel Input

```
In [35]: pd.read_excel('Excel_Sample.xlsx', sheetname='Sheet1')
```

```
Out[35]:
```

	a	b	c	d
0	0	1	2	3
1	4	5	6	7
2	8	9	10	11
3	12	13	14	15

### Excel Output

```
In [33]: df.to_excel('Excel_Sample.xlsx', sheet_name='Sheet1')
```

```
In [36]: from sqlalchemy import create_engine
```

```
In [37]: engine = create_engine('sqlite:///memory:')
```

```
In [40]: df.to_sql('data', engine)
```

```
In [42]: sql_df = pd.read_sql('data', con=engine)
```

```
In [43]: sql_df
```

```
Out[43]:
```

	index	a	b	c	d
0	0	0	1	2	3
1	1	4	5	6	7
2	2	8	9	10	11
3	3	12	13	14	15

## III. Data Storage with Python

### 1. Pandas Introduction

Pandas is a Python library that makes handling tabular data easier. Since we're doing data science - this is something we'll use from time to time!

It's one of three libraries you'll encounter repeatedly in the field of data science:

#### Pandas

Introduces "Data Frames" and "Series" that allow you to slice and dice rows and columns of information.

#### NumPy

Usually you'll encounter "NumPy arrays", which are multi-dimensional array objects. It is easy to create a Pandas DataFrame from a NumPy array, and Pandas DataFrames can be cast as NumPy arrays. NumPy arrays are mainly important because of...

#### Scikit\_Learn

The machine learning library we'll use throughout this course is scikit\_learn, or sklearn, and it generally takes NumPy arrays as its input.

So, a typical thing to do is to load, clean, and manipulate your input data using Pandas. Then convert your Pandas DataFrame into a NumPy array as it's being passed into some Scikit\_Learn function. That conversion can often happen automatically.

Let's start by loading some comma-separated value data using Pandas into a DataFrame:

```
In [1]: %matplotlib inline
import numpy as np
import pandas as pd

df = pd.read_csv("PastHires.csv")
df.head()
```

Out[1]:

	Years Experience	Employed?	Previous employers	Level of Education	Top-tier school	Interned	Hired
0	10	Y	4	BS	N	N	Y
1	0	N	0	BS	Y	Y	Y
2	7	N	6	BS	N	N	N
3	2	Y	1	MS	Y	N	Y
4	20	N	2	PhD	Y	N	N

head() is a handy way to visualize what you've loaded. You can pass it an integer to see some specific number of rows at the beginning of your DataFrame:

```
In [2]: df.head(10)
```

Out[2]:

	Years Experience	Employed?	Previous employers	Level of Education	Top-tier school	Interned	Hired
0	10	Y	4	BS	N	N	Y
1	0	N	0	BS	Y	Y	Y
2	7	N	6	BS	N	N	N
3	2	Y	1	MS	Y	N	Y
4	20	N	2	PhD	Y	N	N
5	0	N	0	PhD	Y	Y	Y
6	5	Y	2	MS	N	Y	Y
7	3	N	1	BS	N	Y	Y
8	15	Y	5	BS	N	N	Y
9	0	N	0	BS	N	N	N

You can also view the end of your data with tail():

```
In [3]: df.tail(4)
```

Out[3]:

	Years Experience	Employed?	Previous employers	Level of Education	Top-tier school	Interned	Hired
9	0	N	0	BS	N	N	N
10	1	N	1	PhD	Y	N	N
11	4	Y	1	BS	N	Y	Y
12	0	N	0	PhD	Y	N	Y

We often talk about the "shape" of your DataFrame. This is just its dimensions. This particular CSV file has 13 rows with 7 columns per row:

```
In [4]: df.shape
```

Out[4]: (13, 7)

The total size of the data frame is the rows \* columns:

```
In [5]: df.size
```

Out[5]: 91

The len() function gives you the number of rows in a DataFrame:

```
In [6]: len(df)
```

Out[6]: 13

If your DataFrame has named columns (in our case, extracted automatically from the first row of a .csv file,) you can get an array of them back:

```
In [7]: df.columns  
Out[7]: Index(['Years Experience', 'Employed?', 'Previous employers',  
               'Level of Education', 'Top-tier school', 'Interned', 'Hired'],  
               dtype='object')
```

Extracting a single column from your DataFrame looks like this - this gives you back a "Series" in Pandas:

```
In [8]: df['Hired']  
Out[8]: 0      Y  
        1      Y  
        2      N  
        3      Y  
        4      N  
        5      Y  
        6      Y  
        7      Y  
        8      Y  
        9      N  
       10     N  
       11     Y  
       12     Y  
Name: Hired, dtype: object
```

You can also extract a given range of rows from a named column, like so:

```
In [9]: df['Hired'][:5]  
Out[9]: 0      Y  
        1      Y  
        2      N  
        3      Y  
        4      N  
Name: Hired, dtype: object
```

Or even extract a single value from a specified column / row combination:

```
In [10]: df['Hired'][5]  
Out[10]: 'Y'
```

To extract more than one column, you pass in a list of column names instead of a single one:

```
In [11]: df[['Years Experience', 'Hired']]  
Out[11]:   Years Experience  Hired  
          0              10      Y  
          1                0      Y  
          2                7      N  
          3                2      Y  
          4              20      N  
          5                0      Y  
          6                5      Y  
          7                3      Y  
          8              15      Y  
          9                0      N  
         10                1      N  
         11                4      Y  
         12                0      Y
```

You can also extract specific ranges of rows from more than one column, in the way you'd expect:

```
In [12]: df[['Years Experience', 'Hired']][:5]
```

```
Out[12]:
```

	Years Experience	Hired
0	10	Y
1	0	Y
2	7	N
3	2	Y
4	20	N

Sorting your DataFrame by a specific column looks like this:

```
In [13]: df.sort_values(['Years Experience'])
```

```
Out[13]:
```

	Years Experience	Employed?	Previous employers	Level of Education	Top-tier school	Interned	Hired
1	0	N	0	BS	Y	Y	Y
5	0	N	0	PhD	Y	Y	Y
9	0	N	0	BS	N	N	N
12	0	N	0	PhD	Y	N	Y
10	1	N	1	PhD	Y	N	N
3	2	Y	1	MS	Y	N	Y
7	3	N	1	BS	N	Y	Y
11	4	Y	1	BS	N	Y	Y
6	5	Y	2	MS	N	Y	Y
2	7	N	6	BS	N	N	N
0	10	Y	4	BS	N	N	Y
8	15	Y	5	BS	N	N	Y
4	20	N	2	PhD	Y	N	N

You can break down the number of unique values in a given column into a Series using value\_counts() - this is a good way to understand the distribution of your data:

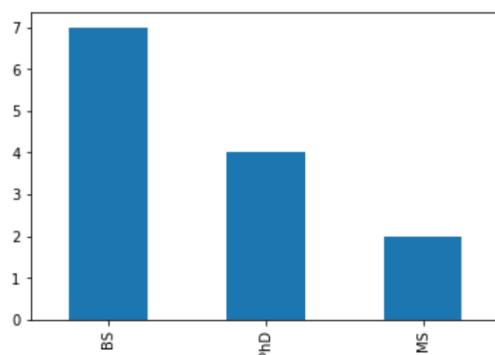
```
In [14]: degree_counts = df['Level of Education'].value_counts()  
degree_counts
```

```
Out[14]: BS    7  
        PhD   4  
        MS    2  
Name: Level of Education, dtype: int64
```

Pandas even makes it easy to plot a Series or DataFrame - just call plot():

```
In [15]: degree_counts.plot(kind='bar')
```

```
Out[15]: <matplotlib.axes._subplots.AxesSubplot at 0x28f6d2b0240>
```



## 2. Series

The first main data type we will learn about for pandas is the Series data type. Let's import Pandas and explore the Series object.

A Series is very similar to a NumPy array (in fact it is built on top of the NumPy array object). What differentiates the NumPy array from a Series, is that a Series can have axis labels, meaning it can be indexed by a label, instead of just a number location. It also doesn't need to hold numeric data, it can hold any arbitrary Python Object.

Let's explore this concept through some examples:

```
In [2]: import numpy as np  
import pandas as pd
```

### a. Creating a Series

You can convert a list, numpy array, or dictionary to a Series:

```
In [3]: labels = ['a', 'b', 'c']  
my_list = [10, 20, 30]  
arr = np.array([10, 20, 30])  
d = {'a': 10, 'b': 20, 'c': 30}
```

#### Using Lists

```
In [4]: pd.Series(data=my_list)
```

```
Out[4]: 0    10  
1    20  
2    30  
dtype: int64
```

```
In [5]: pd.Series(data=my_list, index=labels)
```

```
Out[5]: a    10  
b    20  
c    30  
dtype: int64
```

```
In [6]: pd.Series(my_list, labels)
```

```
Out[6]: a    10  
b    20  
c    30  
dtype: int64
```

#### NumPy Arrays

```
In [7]: pd.Series(arr)
```

```
Out[7]: 0    10  
1    20  
2    30  
dtype: int64
```

```
In [8]: pd.Series(arr, labels)
```

```
Out[8]: a    10  
b    20  
c    30  
dtype: int64
```

#### Dictionary

```
In [9]: pd.Series(d)
```

```
Out[9]: a    10  
b    20  
c    30  
dtype: int64
```

### b. Data in Series

A pandas Series can hold a variety of object types:

```
In [10]: pd.Series(data=labels)

Out[10]: 0    a
          1    b
          2    c
         dtype: object

In [11]: # Even functions (although unlikely that you will use this)
          pd.Series([sum,print,len])

Out[11]: 0      <built-in function sum>
          1      <built-in function print>
          2      <built-in function len>
         dtype: object
```

### c. Using an index

The key to using a Series is understanding its index. Pandas makes use of these index names or numbers by allowing for fast look ups of information (works like a hash table or dictionary). Let's see some examples of how to grab information from a Series. Let us create two series, ser1 and ser2:

```
In [12]: ser1 = pd.Series([1,2,3,4],index = ['USA', 'Germany', 'USSR', 'Japan'])

In [13]: ser1

Out[13]: USA      1
          Germany  2
          USSR     3
          Japan    4
         dtype: int64

In [14]: ser2 = pd.Series([1,2,5,4],index = ['USA', 'Germany','Italy', 'Japan'])

In [15]: ser2

Out[15]: USA      1
          Germany  2
          Italy    5
          Japan    4
         dtype: int64

In [16]: ser1['USA']

Out[16]: 1
```

Operations are then also done based off of index:

```
In [17]: ser1 + ser2

Out[17]: Germany  4.0
          Italy    NaN
          Japan    8.0
          USA     2.0
          USSR    NaN
         dtype: float64
```

Let's stop here for now and move on to DataFrames, which will expand on the concept of Series!

## 3. DataFrames

DataFrames are the workhorse of pandas and are directly inspired by the R programming language. We can think of a DataFrame as a bunch of Series objects put together to share the same index. Let's use pandas to explore this topic!

```
In [183]: import pandas as pd
import numpy as np

In [184]: from numpy.random import randn
np.random.seed(101)

In [185]: df = pd.DataFrame(randn(5,4),index='A B C D E'.split(),columns='W X Y Z'.split())

In [186]: df
```

	W	X	Y	Z
A	2.706850	0.628133	0.907969	0.503826
B	0.651118	-0.319318	-0.848077	0.605965
C	-2.018168	0.740122	0.528813	-0.589001
D	0.188695	-0.758872	-0.933237	0.955057
E	0.190794	1.978757	2.605967	0.683509

## a. Selection and Indexing

Let's learn the various methods to grab data from a DataFrame

```
In [187]: df['W']

Out[187]: A    2.706850
B    0.651118
C   -2.018168
D    0.188695
E    0.190794
Name: W, dtype: float64

In [188]: # Pass a list of column names
df[['W', 'Z']]

Out[188]:
```

	W	Z
A	2.706850	0.503826
B	0.651118	0.605965
C	-2.018168	-0.589001
D	0.188695	0.955057
E	0.190794	0.683509

```
In [189]: # SQL Syntax (NOT RECOMMENDED!)
df.W

Out[189]: A    2.706850
B    0.651118
C   -2.018168
D    0.188695
E    0.190794
Name: W, dtype: float64
```

DataFrame Columns are just Series

```
In [190]: type(df['W'])

Out[190]: pandas.core.series.Series
```

Creating a new column:

```
In [191]: df['new'] = df['W'] + df['Y']

In [192]: df
```

	W	X	Y	Z	new
A	2.706850	0.628133	0.907969	0.503826	3.614819
B	0.651118	-0.319318	-0.848077	0.605965	-0.196959
C	-2.018168	0.740122	0.528813	-0.589001	-1.489355
D	0.188695	-0.758872	-0.933237	0.955057	-0.744542
E	0.190794	1.978757	2.605967	0.683509	2.796762

Removing Columns

```
In [193]: # Return a new DataFrame with the 'new'  
# column dropped  
df.drop('new',axis=1)
```

```
Out[193]:
```

	W	X	Y	Z
A	2.706850	0.628133	0.907969	0.503826
B	0.651118	-0.319318	-0.848077	0.605965
C	-2.018168	0.740122	0.528813	-0.589001
D	0.188695	-0.758872	-0.933237	0.955057
E	0.190794	1.978757	2.605967	0.683509

```
In [194]: # Not inplace unless specified!  
df
```

```
Out[194]:
```

	W	X	Y	Z	new
A	2.706850	0.628133	0.907969	0.503826	3.614819
B	0.651118	-0.319318	-0.848077	0.605965	-0.196959
C	-2.018168	0.740122	0.528813	-0.589001	-1.489355
D	0.188695	-0.758872	-0.933237	0.955057	-0.744542
E	0.190794	1.978757	2.605967	0.683509	2.796762

```
In [195]: # Drop the 'new' column of DataFrame itself  
df.drop('new',axis=1,inplace=True)
```

```
In [196]: df
```

```
Out[196]:
```

	W	X	Y	Z
A	2.706850	0.628133	0.907969	0.503826
B	0.651118	-0.319318	-0.848077	0.605965
C	-2.018168	0.740122	0.528813	-0.589001
D	0.188695	-0.758872	-0.933237	0.955057
E	0.190794	1.978757	2.605967	0.683509

Can also drop rows this way:

```
In [197]: df.drop('E',axis=0)
```

```
Out[197]:
```

	W	X	Y	Z
A	2.706850	0.628133	0.907969	0.503826
B	0.651118	-0.319318	-0.848077	0.605965
C	-2.018168	0.740122	0.528813	-0.589001
D	0.188695	-0.758872	-0.933237	0.955057

Can also drop rows this way:

```
In [197]: df.drop('E',axis=0)
```

```
Out[197]:
```

	W	X	Y	Z
A	2.706850	0.628133	0.907969	0.503826
B	0.651118	-0.319318	-0.848077	0.605965
C	-2.018168	0.740122	0.528813	-0.589001
D	0.188695	-0.758872	-0.933237	0.955057

## Selecting Rows

```
In [198]: df.loc['A']
```

```
Out[198]: W    2.706850  
          X    0.628133  
          Y    0.907969  
          Z    0.503826  
Name: A, dtype: float64
```

Or select based off of position instead of label

```
In [199]: df.iloc[2]
```

```
Out[199]: W    -2.018168  
          X     0.740122  
          Y     0.528813  
          Z    -0.589001  
Name: C, dtype: float64
```

## Selecting subset of rows and columns

```
In [200]: df.loc['B','Y']
```

```
Out[200]: -0.84807698340363147
```

```
In [201]: df.loc[['A','B'],['W','Y']]
```

```
Out[201]:
```

	W	Y
A	2.706850	0.907969
B	0.651118	-0.848077

## b. Conditional Selection

An important feature of pandas is conditional selection using bracket notation, very similar to numpy:

```
In [202]: df
```

```
Out[202]:
```

	W	X	Y	Z
A	2.706850	0.628133	0.907969	0.503826
B	0.651118	-0.319318	-0.848077	0.605965
C	-2.018168	0.740122	0.528813	-0.589001
D	0.188695	-0.758872	-0.933237	0.955057
E	0.190794	1.978757	2.605967	0.683509

```
In [203]: df>0
```

```
Out[203]:
```

	W	X	Y	Z
A	True	True	True	True
B	True	False	False	True
C	False	True	True	False
D	True	False	False	True
E	True	True	True	True

```
In [204]: df[df>0]
```

```
Out[204]:
```

	W	X	Y	Z
A	2.706850	0.628133	0.907969	0.503826
B	0.651118	NaN	NaN	0.605965
C	NaN	0.740122	0.528813	NaN
D	0.188695	NaN	NaN	0.955057
E	0.190794	1.978757	2.605967	0.683509

```
In [205]: df[df['W']>0]
```

```
Out[205]:
```

	W	X	Y	Z
A	2.706850	0.628133	0.907969	0.503826
B	0.651118	-0.319318	-0.848077	0.605965
D	0.188695	-0.758872	-0.933237	0.955057
E	0.190794	1.978757	2.605967	0.683509

```
In [206]: df[df['W']>0]['Y']
```

```
Out[206]:
```

A	0.907969
B	-0.848077
D	-0.933237
E	2.605967

Name: Y, dtype: float64

```
In [207]: df[df['W']>0][['Y', 'X']]
```

```
Out[207]:
```

	Y	X
A	0.907969	0.628133
B	-0.848077	-0.319318
D	-0.933237	-0.758872
E	2.605967	1.978757

For two conditions you can use | and & with parenthesis:

```
In [208]: df[(df['W']>0) & (df['Y'] > 1)]
```

```
Out[208]:
```

	W	X	Y	Z
E	0.190794	1.978757	2.605967	0.683509

## c. More Index Details

Let's discuss some more features of indexing, including resetting the index or setting it something else. We'll also talk about index hierarchy!

```
In [209]: df
```

```
Out[209]:
```

	W	X	Y	Z
A	2.706850	0.628133	0.907969	0.503826
B	0.651118	-0.319318	-0.848077	0.605965
C	-2.018168	0.740122	0.528813	-0.589001
D	0.188695	-0.758872	-0.933237	0.955057
E	0.190794	1.978757	2.605967	0.683509

```
In [210]: # Reset to default 0,1...n index  
df.reset_index()
```

```
Out[210]:
```

index	W	X	Y	Z	
0	A	2.706850	0.628133	0.907969	0.503826
1	B	0.651118	-0.319318	-0.848077	0.605965
2	C	-2.018168	0.740122	0.528813	-0.589001
3	D	0.188695	-0.758872	-0.933237	0.955057
4	E	0.190794	1.978757	2.605967	0.683509

```
In [211]: newwind = 'CA NY WY OR CO'.split()
```

```
In [212]: df['States'] = newwind
```

```
In [213]: df
```

```
Out[213]:
```

	W	X	Y	Z	States
A	2.706850	0.628133	0.907969	0.503826	CA
B	0.651118	-0.319318	-0.848077	0.605965	NY
C	-2.018168	0.740122	0.528813	-0.589001	WY
D	0.188695	-0.758872	-0.933237	0.955057	OR
E	0.190794	1.978757	2.605967	0.683509	CO

```
In [214]: df.set_index('States')
```

```
Out[214]:
```

States	W	X	Y	Z
CA	2.706850	0.628133	0.907969	0.503826
NY	0.651118	-0.319318	-0.848077	0.605965
WY	-2.018168	0.740122	0.528813	-0.589001
OR	0.188695	-0.758872	-0.933237	0.955057
CO	0.190794	1.978757	2.605967	0.683509

```
In [215]: df
```

```
Out[215]:
```

	W	X	Y	Z	States
A	2.706850	0.628133	0.907969	0.503826	CA
B	0.651118	-0.319318	-0.848077	0.605965	NY
C	-2.018168	0.740122	0.528813	-0.589001	WY
D	0.188695	-0.758872	-0.933237	0.955057	OR
E	0.190794	1.978757	2.605967	0.683509	CO

```
In [216]: df.set_index('States', inplace=True)
```

```
In [218]: df
```

```
Out[218]:
```

States	W	X	Y	Z
CA	2.706850	0.628133	0.907969	0.503826
NY	0.651118	-0.319318	-0.848077	0.605965
WY	-2.018168	0.740122	0.528813	-0.589001
OR	0.188695	-0.758872	-0.933237	0.955057
CO	0.190794	1.978757	2.605967	0.683509

#### d. Multi-Index and Index Hierarchy

Let us go over how to work with Multi-Index, first we'll create a quick example of what a Multi-Indexed DataFrame would look like:

```
In [253]: # Index Levels
outside = ['G1','G1','G1','G2','G2','G2']
inside = [1,2,3,1,2,3]
hier_index = list(zip(outside,inside))
hier_index = pd.MultiIndex.from_tuples(hier_index)

In [254]: hier_index
Out[254]: MultiIndex(levels=[[ 'G1', 'G2'], [1, 2, 3]],
                       labels=[[0, 0, 0, 1, 1, 1], [0, 1, 2, 0, 1, 2]])

Out[254]: MultiIndex(levels=[[ 'G1', 'G2'], [1, 2, 3]],
                       labels=[[0, 0, 0, 1, 1, 1], [0, 1, 2, 0, 1, 2]])

In [257]: df = pd.DataFrame(np.random.randn(6,2),index=hier_index,columns=[ 'A', 'B'])
df

Out[257]:
```

	A	B
1	0.153661	0.167638
G1 2	-0.765930	0.962299
3	0.902826	-0.537909
1	-1.549671	0.435253
G2 2	1.259904	-0.447898
3	0.266207	0.412580

Now let's show how to index this! For index hierarchy we use `df.loc[]`, if this was on the columns axis, you would just use normal bracket notation `df[]`. Calling one level of the index returns the sub-dataframe:

```
In [260]: df.loc['G1']

Out[260]:
```

	A	B
1	0.153661	0.167638
2	-0.765930	0.962299
3	0.902826	-0.537909

```
In [263]: df.loc['G1'].loc[1]

Out[263]: A      0.153661
          B      0.167638
          Name: 1, dtype: float64

In [265]: df.index.names
Out[265]: FrozenList([None, None])

In [266]: df.index.names = [ 'Group', 'Num' ]

In [267]: df
Out[267]:
```

	A	B
Group Num		
1	0.153661	0.167638
G1 2	-0.765930	0.962299
3	0.902826	-0.537909
1	-1.549671	0.435253
G2 2	1.259904	-0.447898
3	0.266207	0.412580

```
In [270]: df.xs('G1')

Out[270]:
```

	A	B
Num		
1	0.153661	0.167638
2	-0.765930	0.962299
3	0.902826	-0.537909

```
In [271]: df.xs(['G1',1])
Out[271]: A    0.153661
           B    0.167638
           Name: (G1, 1), dtype: float64

In [273]: df.xs(1,level='Num')
Out[273]:      A      B
Group
G1  0.153661  0.167638
G2 -1.549671  0.435253
```

## IV. Data Cleaning with Python

### 1. Missing Data

Let's show a few convenient methods to deal with Missing Data in pandas:

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

In [9]: df = pd.DataFrame({'A':[1,2,np.nan],
                           'B':[5,np.nan,np.nan],
                           'C':[1,2,3]})

In [10]: df
Out[10]:      A      B      C
0   1.0    5.0    1
1   2.0    NaN    2
2   NaN    NaN    3

In [12]: df.dropna()
Out[12]:      A      B      C
0   1.0    5.0    1

In [13]: df.dropna(axis=1)
Out[13]:      C
0   1
1   2
2   3

In [14]: df.dropna(thresh=2)
Out[14]:      A      B      C
0   1.0    5.0    1
1   2.0    NaN    2

In [15]: df.fillna(value='FILL VALUE')
Out[15]:      A          B      C
0       1         5  1
1       2  FILL VALUE  2
2  FILL VALUE  FILL VALUE  3

In [17]: df['A'].fillna(value=df['A'].mean())
Out[17]: 0    1.0
           1    2.0
           2    1.5
           Name: A, dtype: float64
```

## 2. GroupBy

The groupby method allows you to group rows of data together and call aggregate functions

```
In [31]: import pandas as pd
# Create dataframe
data = {'Company': ['GOOG', 'GOOG', 'MSFT', 'MSFT', 'FB', 'FB'],
        'Person': ['Sam', 'Charlie', 'Amy', 'Vanessa', 'Carl', 'Sarah'],
        'Sales': [200, 120, 340, 124, 243, 350]}
```

```
In [32]: df = pd.DataFrame(data)
```

```
In [33]: df
```

```
Out[33]:   Company Person Sales
0      GOOG     Sam    200
1      GOOG  Charlie   120
2      MSFT     Amy    340
3      MSFT  Vanessa   124
4         FB     Carl   243
5         FB    Sarah   350
```

Now you can use the .groupby() method to group rows together based off of a column name. For instance let's group based off of Company. This will create a DataFrameGroupBy object:

```
In [34]: df.groupby('Company')
```

```
Out[34]: <pandas.core.groupby.DataFrameGroupBy object at 0x113014128>
```

You can save this object as a new variable:

```
In [35]: by_comp = df.groupby("Company")
```

And then call aggregate methods off the object:

```
In [36]: by_comp.mean()
```

```
Out[36]:          Sales
Company
FB    296.5
GOOG 160.0
MSFT 232.0
```

```
In [37]: df.groupby('Company').mean()
```

```
Out[37]:          Sales
Company
FB    296.5
GOOG 160.0
MSFT 232.0
```

More examples of aggregate methods:

```
In [38]: by_comp.std()
```

```
Out[38]:          Sales
Company
FB    75.660426
GOOG 56.568542
MSFT 152.735065
```

```
In [39]: by_comp.min()
```

```
Out[39]:      Person  Sales
Company
FB      Carl    243
GOOG   Charlie   120
MSFT   Amy     124
```

```
In [40]: by_comp.max()
```

```
Out[40]:
```

Person Sales		
Company		
FB	Sarah	350
GOOG	Sam	200
MSFT	Vanessa	340

```
In [41]: by_comp.count()
```

```
Out[41]:
```

Person Sales		
Company		
FB	2	2
GOOG	2	2
MSFT	2	2

```
In [42]: by_comp.describe()
```

```
Out[42]:
```

Sales	
Company	
count	2.000000
mean	296.500000
std	75.660426
FB	min 243.000000
	25% 269.750000
	50% 296.500000
	75% 323.250000
	max 350.000000
count	2.000000
mean	160.000000
std	56.568542
GOOG	min 120.000000
	25% 140.000000
	50% 160.000000
	75% 180.000000
	max 200.000000
count	2.000000
mean	232.000000
std	152.735065

```
In [43]: by_comp.describe().transpose()
```

```
Out[43]:
```

Company	FB	GOOG
count	2.0	2.0
mean	296.5	160.0
std	75.660426	56.568542
min	243.0	120.0
25%	269.75	140.0
50%	296.5	160.0
75%	323.25	180.0
max	350.0	200.0

1 rows × 24 columns

```
In [44]: by_comp.describe().transpose()['GOOG']
```

```
Out[44]:
```

	count	mean	std	min	25%	50%	75%	max
Sales	2.0	160.0	56.568542	120.0	140.0	160.0	180.0	200.0

### 3. Merging, Joining and Concatenating

There are 3 main ways of combining DataFrames together: Merging, Joining and Concatenating. In this lecture we will discuss these 3 methods with examples.

#### a. Concatenation

Example DataFrame

```
In [3]: import pandas as pd
```

```
In [4]: df1 = pd.DataFrame({'A': ['A0', 'A1', 'A2', 'A3'],
                           'B': ['B0', 'B1', 'B2', 'B3'],
                           'C': ['C0', 'C1', 'C2', 'C3'],
                           'D': ['D0', 'D1', 'D2', 'D3']},
                           index=[0, 1, 2, 3])
```

```
In [5]: df2 = pd.DataFrame({'A': ['A4', 'A5', 'A6', 'A7'],
                           'B': ['B4', 'B5', 'B6', 'B7'],
                           'C': ['C4', 'C5', 'C6', 'C7'],
                           'D': ['D4', 'D5', 'D6', 'D7']},
                           index=[4, 5, 6, 7])
```

```
In [6]: df3 = pd.DataFrame({'A': ['A8', 'A9', 'A10', 'A11'],
                           'B': ['B8', 'B9', 'B10', 'B11'],
                           'C': ['C8', 'C9', 'C10', 'C11'],
                           'D': ['D8', 'D9', 'D10', 'D11']},
                           index=[8, 9, 10, 11])
```

```
In [7]: df1
```

```
Out[7]:   A   B   C   D
          0   A0   B0   C0   D0
          1   A1   B1   C1   D1
          2   A2   B2   C2   D2
          3   A3   B3   C3   D3
```

```
In [8]: df2
```

```
Out[8]:   A   B   C   D
          4   A4   B4   C4   D4
          5   A5   B5   C5   D5
          6   A6   B6   C6   D6
          7   A7   B7   C7   D7
```

```
In [12]: df3
```

```
Out[12]:   A   B   C   D
          8   A8   B8   C8   D8
          9   A9   B9   C9   D9
          10  A10  B10  C10  D10
          11  A11  B11  C11  D11
```

Concatenation basically glues together DataFrames. Keep in mind that dimensions should match along the axis you are concatenating on. You can use **pd.concat** and pass in a list of DataFrames to concatenate together:

```
In [10]: pd.concat([df1, df2, df3])
```

```
Out[10]:   A   B   C   D
          0   A0   B0   C0   D0
          1   A1   B1   C1   D1
          2   A2   B2   C2   D2
          3   A3   B3   C3   D3
          4   A4   B4   C4   D4
          5   A5   B5   C5   D5
          6   A6   B6   C6   D6
          7   A7   B7   C7   D7
          8   A8   B8   C8   D8
          9   A9   B9   C9   D9
          10  A10  B10  C10  D10
          11  A11  B11  C11  D11
```

```
In [18]: pd.concat([df1,df2,df3],axis=1)
```

```
Out[18]:
```

	A	B	C	D	A	B	C	D	A	B	C	D
0	A0	B0	C0	D0	NaN							
1	A1	B1	C1	D1	NaN							
2	A2	B2	C2	D2	NaN							
3	A3	B3	C3	D3	NaN							
4	NaN	NaN	NaN	NaN	A4	B4	C4	D4	NaN	NaN	NaN	NaN
5	NaN	NaN	NaN	NaN	A5	B5	C5	D5	NaN	NaN	NaN	NaN
6	NaN	NaN	NaN	NaN	A6	B6	C6	D6	NaN	NaN	NaN	NaN
7	NaN	NaN	NaN	NaN	A7	B7	C7	D7	NaN	NaN	NaN	NaN
8	NaN	A8	B8	C8	D8							
9	NaN	A9	B9	C9	D9							
10	NaN	A10	B10	C10	D10							
11	NaN	A11	B11	C11	D11							

## b. Merging

Example DataFrame

```
In [28]: left = pd.DataFrame({'key': ['K0', 'K1', 'K2', 'K3'],
                           'A': ['A0', 'A1', 'A2', 'A3'],
                           'B': ['B0', 'B1', 'B2', 'B3']})
```

```
right = pd.DataFrame({'key': ['K0', 'K1', 'K2', 'K3'],
                      'C': ['C0', 'C1', 'C2', 'C3'],
                      'D': ['D0', 'D1', 'D2', 'D3']})
```

```
In [29]: left
```

```
Out[29]:
```

	A	B	key
0	A0	B0	K0
1	A1	B1	K1
2	A2	B2	K2
3	A3	B3	K3

```
In [30]: right
```

```
Out[30]:
```

	C	D	key
0	C0	D0	K0
1	C1	D1	K1
2	C2	D2	K2
3	C3	D3	K3

The **merge** function allows you to merge DataFrames together using a similar logic as merging SQL Tables together. For example:

```
In [35]: pd.merge(left,right,how='inner',on='key')
```

```
Out[35]:
```

	A	B	key	C	D
0	A0	B0	K0	C0	D0
1	A1	B1	K1	C1	D1
2	A2	B2	K2	C2	D2
3	A3	B3	K3	C3	D3

Or to show a more complicated example:

```
In [37]: left = pd.DataFrame({'key1': ['K0', 'K0', 'K1', 'K2'],
                           'key2': ['K0', 'K1', 'K0', 'K1'],
                           'A': ['A0', 'A1', 'A2', 'A3'],
                           'B': ['B0', 'B1', 'B2', 'B3']})
```

```
right = pd.DataFrame({'key1': ['K0', 'K1', 'K1', 'K2'],
                      'key2': ['K0', 'K0', 'K0', 'K0'],
                      'C': ['C0', 'C1', 'C2', 'C3'],
                      'D': ['D0', 'D1', 'D2', 'D3']})
```

```
In [39]: pd.merge(left, right, on=['key1', 'key2'])
```

```
Out[39]:
```

	A	B	key1	key2	C	D
0	A0	B0	K0	K0	C0	D0
1	A2	B2	K1	K0	C1	D1
2	A2	B2	K1	K0	C2	D2

```
In [40]: pd.merge(left, right, how='outer', on=['key1', 'key2'])
```

```
Out[40]:
```

	A	B	key1	key2	C	D
0	A0	B0	K0	K0	C0	D0
1	A1	B1	K0	K1	NaN	NaN
2	A2	B2	K1	K0	C1	D1
3	A2	B2	K1	K0	C2	D2
4	A3	B3	K2	K1	NaN	NaN
5	NaN	NaN	K2	K0	C3	D3

```
In [41]: pd.merge(left, right, how='right', on=['key1', 'key2'])
```

```
Out[41]:
```

	A	B	key1	key2	C	D
0	A0	B0	K0	K0	C0	D0
1	A2	B2	K1	K0	C1	D1
2	A2	B2	K1	K0	C2	D2
3	NaN	NaN	K2	K0	C3	D3

```
In [42]: pd.merge(left, right, how='left', on=['key1', 'key2'])
```

```
Out[42]:
```

	A	B	key1	key2	C	D
0	A0	B0	K0	K0	C0	D0
1	A1	B1	K0	K1	NaN	NaN
2	A2	B2	K1	K0	C1	D1
3	A2	B2	K1	K0	C2	D2
4	A3	B3	K2	K1	NaN	NaN

## c. Joining

Joining is a convenient method for combining the columns of two potentially differently-indexed DataFrames into a single result DataFrame.

```
In [46]: left = pd.DataFrame({'A': ['A0', 'A1', 'A2'],
                           'B': ['B0', 'B1', 'B2'],
                           index=['K0', 'K1', 'K2'])

right = pd.DataFrame({'C': ['C0', 'C2', 'C3'],
                      'D': ['D0', 'D2', 'D3'],
                      index=['K0', 'K2', 'K3'])
```

```
In [47]: left.join(right)
```

```
Out[47]:
```

	A	B	C	D
K0	A0	B0	C0	D0
K1	A1	B1	NaN	NaN
K2	A2	B2	C2	D2

```
In [48]: left.join(right, how='outer')
```

```
Out[48]:
```

	A	B	C	D
K0	A0	B0	C0	D0
K1	A1	B1	NaN	NaN
K2	A2	B2	C2	D2
K3	NaN	NaN	C3	D3

## 4. Operations

There are lots of operations with pandas that will be really useful to you, but don't fall into any distinct category. Let's show them here in this lecture:

```
In [5]: import pandas as pd
df = pd.DataFrame({'col1':[1,2,3,4], 'col2':[444,555,666,444], 'col3':['abc','def','ghi','xyz']})

Out[5]:   col1  col2  col3
0      1    444    abc
1      2    555    def
2      3    666    ghi
3      4    444    xyz
```

### a. Info on Unique Values

```
In [53]: df['col2'].unique()
Out[53]: array([444, 555, 666])

In [54]: df['col2'].nunique()
Out[54]: 3

In [55]: df['col2'].value_counts()
Out[55]: 444    2
         555    1
         666    1
Name: col2, dtype: int64
```

### b. Selecting Data

```
In [56]: #Select from DataFrame using criteria from multiple columns
newdf = df[(df['col1']>2) & (df['col2']==444)]

In [57]: newdf
Out[57]:   col1  col2  col3
3      4    444    xyz
```

### c. Applying Functions

```
In [58]: def times2(x):
           return x*2

In [59]: df['col1'].apply(times2)
Out[59]: 0    2
         1    4
         2    6
         3    8
Name: col1, dtype: int64

In [60]: df['col3'].apply(len)
Out[60]: 0    3
         1    3
         2    3
         3    3
Name: col3, dtype: int64

In [61]: df['col1'].sum()
Out[61]: 10
```

#### d. Permanently Removing a Column

```
In [62]: del df['col1']
```

```
In [63]: df
```

```
Out[63]:   col2  col3
0    444  abc
1    555  def
2    666  ghi
3    444  xyz
```

#### e. Get column and index names:

```
In [64]: df.columns
```

```
Out[64]: Index(['col2', 'col3'], dtype='object')
```

```
In [65]: df.index
```

```
Out[65]: RangeIndex(start=0, stop=4, step=1)
```

#### f. Sorting and Ordering a DataFrame:

```
In [66]: df
```

```
Out[66]:   col2  col3
0    444  abc
1    555  def
2    666  ghi
3    444  xyz
```

```
In [67]: df.sort_values(by='col2') #inplace=False by default
```

```
Out[67]:   col2  col3
0    444  abc
3    444  xyz
1    555  def
2    666  ghi
```

#### g. Find Null Values or Check for Null Values

```
In [68]: df.isnull()
```

```
Out[68]:   col2  col3
0  False  False
1  False  False
2  False  False
3  False  False
```

```
In [69]: # Drop rows with NaN Values
df.dropna()
```

```
Out[69]:   col2  col3
0    444  abc
1    555  def
2    666  ghi
3    444  xyz
```

## h. Filling in NaN values with something else:

```
In [3]: import numpy as np
```

```
In [6]: df = pd.DataFrame({'col1':[1,2,3,np.nan],
                           'col2':[np.nan,555,666,444],
                           'col3':['abc','def','ghi','xyz']})
df.head()
```

```
Out[6]:   col1  col2  col3
0    1.0    NaN    abc
1    2.0  555.0    def
2    3.0  666.0    ghi
3    NaN  444.0    xyz
```

```
In [7]: df.isnull()
```

```
Out[7]:   col1  col2  col3
0  False  True  False
1  False  False  False
2  False  False  False
3  True  False  False
```

```
In [8]: df.dropna()
```

```
Out[8]:   col1  col2  col3
1    2.0  555.0    def
2    3.0  666.0    ghi
```

```
In [9]: df.fillna('FILL')
```

```
Out[9]:   col1  col2  col3
0      1    FILL    abc
1      2     555    def
2      3     666    ghi
3    FILL     444    xyz
```

```
In [89]: data = {'A': ['foo', 'foo', 'foo', 'bar', 'bar', 'bar'],
               'B': ['one', 'one', 'two', 'two', 'one', 'one'],
               'C': ['x', 'y', 'x', 'y', 'x', 'y'],
               'D': [1, 3, 2, 5, 4, 1]}
df = pd.DataFrame(data)
```

```
In [90]: df
```

```
Out[90]:   A   B   C   D
0  foo  one  x  1
1  foo  one  y  3
2  foo  two  x  2
3  bar  two  y  5
4  bar  one  x  4
5  bar  one  y  1
```

```
In [91]: df.pivot_table(values='D', index=['A', 'B'], columns=['C'])
```

```
Out[91]:   C   x   y
          A   B
bar  one  4.0  1.0
      two  NaN  5.0
foo  one  1.0  3.0
      two  2.0  NaN
```

## V. Exercises

### 1. Sales

Fill in the TODO cells in sales.ipynb notebook.

- ❖ Fix column datatypes.
- ❖ Drop if duplicated or null.
- ❖ Sanity check for value ranges and to check assumptions
- ❖ Use regular expression and lambda function to parse data.

### 2. Job Market

Given the job market data in csv file. Create your own jupyter notebook and explore the data by:

- ❖ Load the data using Pandas.
- ❖ Visualize top 10 first rows
- ❖ Fix column datatypes.
- ❖ Aggregate existing columns into new column.

### 3. Web Scraping with BeautifulSoup – IMDB (OPTIONAL)

Write a Python script to download IMDB 250 Top Rated Movies. For each movie, you'll need to retrieve the movie title, the ranking, the initial release year, and the rating. Your data must be stored in a proper imdb\_top\_250.csv file.

(You can implement your own code to get the same result)

```
import requests, csv
from bs4 import BeautifulSoup

def get_movies(url):
    response = requests.get(url)
    soup_imdb = BeautifulSoup(response.text)

    all_movies = soup_imdb.find_all("li", {"class": "ipc-metadata-list-summary-item"})

    # get movie title :
    titles = []

    # get ranking :
    rankings = []

    # get release year :
    years = []

    # get rating :
    ratings = []

    mega_list = list(zip(titles, rankings, years, ratings))
    mega_list = [list(elt) for elt in mega_list]

    # Write csv
    str_lst = [f"{mega_list[i][1]} / {mega_list[i][0]} ({mega_list[i][2]}) / Starring: {mega_list[i][3]}" \
        for i, val in enumerate(mega_list)]

    res = [elt.split("/") for elt in str_lst]

    with open("imdb_top_250.csv", "w") as f:
        writer = csv.writer(f, delimiter="-")
        writer.writerows(res)
```

```
def main():
    url = "https://www.imdb.com/chart/top"
    get_movies(url)
```

```
if __name__ == "__main__":
    main()

0   1   The Shawshank Redemption (1994)   Starring: 9.3
1   2           The Godfather (1972)   Starring: 9.2
2   3           The Dark Knight (2008)   Starring: 9.0
3   4           The Godfather Part II (1974)   Starring: 9.0
4   5           12 Angry Men (1957)   Starring: 9.0
```