CORK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ

Practical Machine Learning

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Lecture: Introduction to using Pandas

Ted Scully

Pandas

- NumPy is a great tool for dealing with **numeric matrices** and vectors in Python
  - For more complex data, it is limited.

- Fortunately, when dealing with complex data we can use the **powerful Python data analysis toolkit** (a.k.a. pandas).

- Pandas is an open source library providing high-performance, easy-to-use data structures for the Python programming language.
  - Used primarily for data manipulation and analysis.

- Resources
  - https://pandas.pydata.org/docs/reference/index.html

Data Structures in Pandas

- Pandas introduces two new data structures to Python –
  - **Series**
  - **DataFrame**

- Both of which are built on top of NumPy (which means it's very fast).

- **A Series** is a one-dimensional object similar to an array, list, or column in a table.

- Pandas will assign a **labelled index** to each item in the Series.
  - By default, each item will receive an index label from 0 to N, where N is the length of the Series minus one.

  - **S = Series(data, index = index)**
    - The data can be many different things such as a NumPy arrays, list of scalar values, dictionary

Series - Examples

You will notice the syntax and functionality used in a Series object is quite similar to that of a NumPy array.

```
import numpy as np
import pandas as pd


s1 = pd.Series(np.random.randn(5))

print (s1)


print (s1[1])

print (s1[ [1, 2] ])

print (s1[[True,False, False, False, True]])

print (s1[0:3])

print (np.square(s1))
```

```
0   -0.635304
1   -1.314937
2   -0.006525
3   -1.223736
4    0.188021
dtype: float64

-1.3149367389155941
```

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print (s1[0:3])

print (np.square(s1))
```

```
0   -0.635304
1   -1.314937
2   -0.006525
dtype: float64

0    0.403612
1    1.729059
2    0.000043
3    1.497530
4    0.035352
dtype: float64
```

Series

- We can use conditional statements in the same way as we saw with NumPy
  - **irishCities <200** returns a Series of True/False values, which we then pass to our Series cities, returning the corresponding True items.

```
# Dictionary with annual car robberies in each Irish city
d = {'Dublin': 245, 'Cork': 150, 'Limerick': 125,' Galway': 360, 'Belfast': 300}

irishCities = pd.Series(d)

print (irishCities [ irishCities <200  ]  )

print ( type ( irishCities[irishCities <200] ) )
```

```
Belfast     300
Cork        150
Dublin      245
Galway      360
Limerick    125
dtype: int64
```

As with NumPy, Boolean indexing like this creates a **separate copy** of the data. The original series and the one returned by the relational operator don't refer to the same copy of the same data.

```
Cork        150
Limerick    125
dtype: int64
<class 'pandas.core.series.Series'>
```

Data Frame

- A DataFrame is a data structure comprised of **rows and columns** of data.
  - It is similar to a spreadsheet or a database table.
  - You can also think of a DataFrame as a **collection of Series objects** that share an index

- The syntax for creating a data frame is as follows:
  - ***DataFrame(data, columns=listOfColumns)***

- Using the columns parameter allows us to tell the constructor how we'd like the columns ordered.

Creating a Dataframe from a NumPy Array

- In the example below we create a dataframe from a 2D NumPy array. The array is passed as an argument when the dataframe is created.

```
import pandas as pd
import numpy as np

arr = np.array([[1, 2, 3], [4, 5, 6], [7, 8, 9]], float)

df = pd.DataFrame( arr )

print (df)
```

	0	1	2
0	1.0	2.0	3.0
1	4.0	5.0	6.0
2	7.0	8.0	9.0

Creating a DataFrame

- Remember we mentioned you can view a dataset as a group of Series object. Here create a DataFrame by passing it a number of Series objects.

```
seriesA = pd.Series( np.random.rand(3), index=['a', 'b', 'c']  )
seriesB = pd.Series( np.random.rand(4), index=['a', 'b', 'c', 'd'] )
seriesC = pd.Series( np.random.rand(3), index=['b', 'c', 'd'] )

df = pd.DataFrame( { 'one' : seriesA,
                     'two' : seriesB,
                     'three' : seriesC } )
print (df)
```

	one	three	two
a	0.307010	**NaN**	0.396005
b	0.671142	0.263916	0.532836
c	0.116057	0.839463	0.826531
d	**NaN**	0.439335	0.984332

Revert from DataFrame to NumPy Array

- It is very easy to convert from a DataFrame object to a NumPy array using .to_numpy().
- We can also convert a **Series object** to a NumPy array in the same way!

```
import pandas as pd
import numpy as np

arr = np.array([[1, 2, 3], [4, 5, 6], [7, 8, 9]], float)

df = pd.DataFrame( arr )

dataArr = df.to_numpy()

print (dataArr)
print (type(dataArr))
```

```
     0    1    2
0   1.0  2.0  3.0
1   4.0  5.0  6.0
2   7.0  8.0  9.0

[[ 1.  2.  3.]
 [ 4.  5.  6.]
 [ 7.  8.  9.]]

<class 'numpy.ndarray'>
```

Dataframe

- The most common way of creating a dataframe is by reading existing data directly into a dataframe

- There are a number of ways of doing this
  - read_csv
  - read_excel
  - read_hdf
  - read_sql
  - read_json
  - read_sas …

- We will look at how to read from a CSV file.

Titanic - Dataset

Available as .csv file on Blackboard.

VARIABLE DESCRIPTIONS:

survival Survival
(0 = No; 1 = Yes)

pclass Passenger Class
(1 = 1st; 2 = 2nd; 3 = 3rd)

name Name

sex Sex

age Age

sibsp Number of Siblings/Spouses Aboard

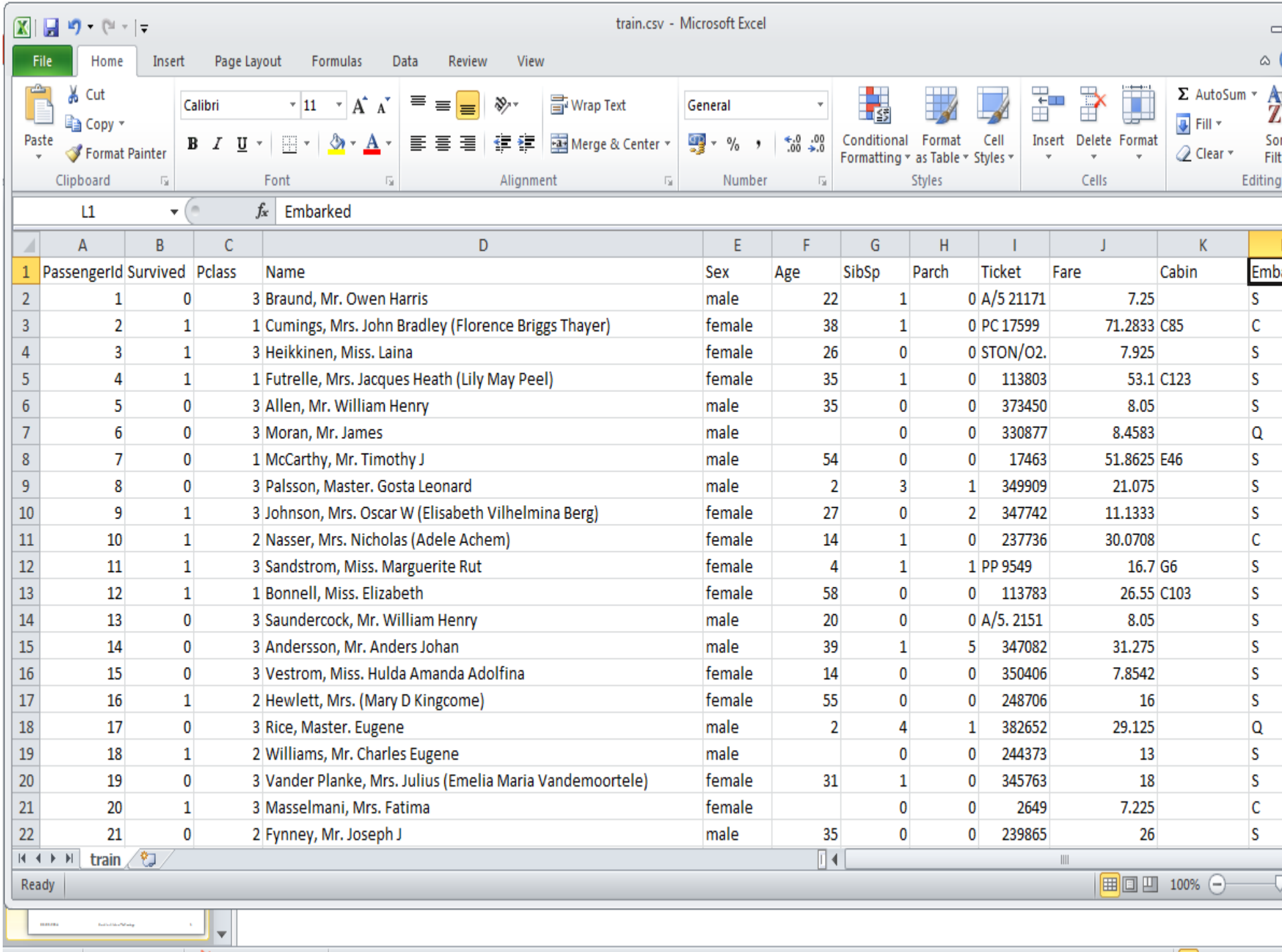
parch Number of Parents/Children Aboard

ticket Ticket Number

fare Passenger Fare

cabin Cabin

embarked Port of Embarkation
(C = Cherbourg; Q = Queenstown; S = Southampton)



	A	B	C	D	E	F	G	H	I	J	K	
1	PassengerId	Survived	Pclass	Name	Sex	Age	SibSp	Parch	Ticket	Fare	Cabin	Emb
2	1	0	3	Braund, Mr. Owen Harris	male	22	1	0	A/5 21171	7.25		S
3	2	1	1	Cumings, Mrs. John Bradley (Florence Briggs Thayer)	female	38	1	0	PC 17599	71.2833	C85	C
4	3	1	3	Heikkinen, Miss. Laina	female	26	0	0	STON/O2.	7.925		S
5	4	1	1	Futrelle, Mrs. Jacques Heath (Lily May Peel)	female	35	1	0	113803	53.1	C123	S
6	5	0	3	Allen, Mr. William Henry	male	35	0	0	373450	8.05		S
7	6	0	3	Moran, Mr. James	male		0	0	330877	8.4583		Q
8	7	0	1	McCarthy, Mr. Timothy J	male	54	0	0	17463	51.8625	E46	S
9	8	0	3	Palsson, Master. Gosta Leonard	male	2	3	1	349909	21.075		S
10	9	1	3	Johnson, Mrs. Oscar W (Elisabeth Vilhelmina Berg)	female	27	0	2	347742	11.1333		S
11	10	1	2	Nasser, Mrs. Nicholas (Adele Achem)	female	14	1	0	237736	30.0708		C
12	11	1	3	Sandstrom, Miss. Marguerite Rut	female	4	1	1	PP 9549	16.7	G6	S
13	12	1	1	Bonnell, Miss. Elizabeth	female	58	0	0	113783	26.55	C103	S
14	13	0	3	Saundercock, Mr. William Henry	male	20	0	0	A/5. 2151	8.05		S
15	14	0	3	Andersson, Mr. Anders Johan	male	39	1	5	347082	31.275		S
16	15	0	3	Vestrom, Miss. Hulda Amanda Adolfina	female	14	0	0	350406	7.8542		S
17	16	1	2	Hewlett, Mrs. (Mary D Kingcome)	female	55	0	0	248706	16		S
18	17	0	3	Rice, Master. Eugene	male	2	4	1	382652	29.125		Q
19	18	1	2	Williams, Mr. Charles Eugene	male		0	0	244373	13		S
20	19	0	3	Vander Planke, Mrs. Julius (Emelia Maria Vandemoortele)	female	31	1	0	345763	18		S
21	20	1	3	Masselmani, Mrs. Fatima	female		0	0	2649	7.225		C
22	21	0	2	Fynney, Mr. Joseph J	male	35	0	0	239865	26		S

Describing a DataFrame

- To pull in the text file, we will use the pandas function *read_csv* method.
- The read_csv has a very large number of parameters such as specifying the delimiter, included headers, etc
- Typically it's not very useful to print out an entire dataframe.
- However, there are some useful functions you can use to get summary data.

```
import pandas as pd

df = pd.read_csv("titanic.csv")

print (df.info())
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 891 entries, 0 to 890
Data columns (total 12 columns):
PassengerId    891 non-null int64
Survived       891 non-null int64
Pclass         891 non-null int64
Name           891 non-null object
Sex            891 non-null object
Age            714 non-null float64
SibSp          891 non-null int64
Parch          891 non-null int64
Ticket         891 non-null object
Fare           891 non-null float64
Cabin          204 non-null object
Embarked       889 non-null object
dtypes: float64(2), int64(5), object(5)
memory usage: 83.6+ KB
None
```

Describing a DataFrame

- DataFrame's also have a useful **describe** method, which is used for viewing **basic statistics** about the dataset's numeric columns.
  - It will return information on all columns of a numeric datatype, therefore some of the data may not be of use .
  - The data type of what is returned is itself a dataframe

```
df = pd.read_csv("titanic.csv")

print (type(df))

print ( df.describe() )
```

	PassengerId	Survived	Pclass	Age	SibSp	\
count	891.000000	891.000000	891.000000	714.000000	891.000000	
mean	446.000000	0.383838	2.308642	29.699118	0.523008	
std	257.353842	0.486592	0.836071	14.526497	1.102743	
min	1.000000	0.000000	1.000000	0.420000	0.000000	
25%	223.500000	0.000000	2.000000	20.125000	0.000000	
50%	446.000000	0.000000	3.000000	28.000000	0.000000	
75%	668.500000	1.000000	3.000000	38.000000	1.000000	
max	891.000000	1.000000	3.000000	80.000000	8.000000	

	Parch	Fare
count	891.000000	891.000000
mean	0.381594	32.204208
std	0.806057	49.693429
min	0.000000	0.000000
25%	0.000000	7.910400
50%	0.000000	14.454200
75%	0.000000	31.000000
max	6.000000	512.329200

We can easily see the average age of the passengers is 29.6 years old, with the youngest being 0.42 and the oldest being 80. The median age is 28, with the youngest quartile of users being 20 or younger, and the oldest quartile being at least 38

Accessing Column Data

- To select a column in a dataframe, we index with the name of the column:
- **dataframe[‘columnName’]**

```
df = pd.read_csv("titanic.csv")

print ( df['Age'] )
```

- Note this column is returned as a **Series object.**

Alternatively, a column of data may be accessed using the **dot notation** with the column name as an attribute (df.Age). Although it works with this particular example, it is not best practice and is prone to error and misuse. Column names with spaces or special characters cannot be accessed in this manner.

```
4      35.0
5       NaN
6      54.0
7       2.0
8      27.0
9      14.0
10      4.0
11     58.0
12     20.0
13     39.0
14     14.0
15     55.0
16      2.0
17      NaN
18     31.0
19      NaN
       ...
867    31.0
868     NaN
869     4.0
870    26.0
871    47.0
872    33.0
873    47.0
874    28.0
875    15.0
876    20.0
877    19.0
878     NaN
879    56.0
880    25.0
881    33.0
882    22.0
883    28.0
884    25.0
885    39.0
886    27.0
887    19.0
888     NaN
889    26.0
890    32.0
Name: Age, Length: 891, dtype: float64
```

Accessing Columns

- We mentioned in a previous slide that you can also think of a DataFrame as a **group of Series objects** that share an index. When you access an individual column from a dataframe the data type returned is a series.
- Note if you extract multiple columns the data type returned is still a DataFrame.

```
df = pd.read_csv("titanic.csv")

ages = df['Age']
print (type(ages))

moreInfo = df[['Age', 'Name']]
print (type(moreInfo))
```

```
<class 'pandas.core.series.Series'>
<class 'pandas.core.frame.DataFrame'>
```

Using Head and Tail

- To view a small sample of a **Series or DataFrame** object, use the head (start) and tail (end) methods. The default number of elements to display is five, but you can pass a number as an argument.

```
df = pd.read_csv("titanic.csv")
freqAges = df['Age']
print (freqAges.head())

print (freqAges.tail())
```

```
>>>
0     22
1     38
2     26
3     35
4     35
Name: Age, dtype: float64

886    27
887    19
888   NaN
889    26
890    32
Name: Age, dtype: float64
>>>
```

- If I want to capture the last 7 age values in the dataset

```
df = pd.read_csv("titanic.csv")
print (df["Age"].tail(7))
```

Using loc and iloc

- A DataFrame consists of both rows and columns, and as a result has constructs to select data from specific rows and columns.
- We have already seen the use of **[]** but Pandas also allows us to access data using .loc[], and .iloc[].
- The **.loc** function is primarily **label based indexing**
- The **iloc** function is used for **integer-location based indexing** and is similar to what we used in NumPy
- Both .loc and .iloc work with Series and DataFrame objects.

Using loc

- Pandas loc allows us to access a group of rows and columns by label(s) or using a Boolean array.

- The allowable inputs can be (from Pandas API):
  - A single label, e.g. 5 or 'a', (note that 5 is interpreted as a label of the index, and never as an integer position along the index).
  - A list or array of labels, e.g. ['a', 'b', 'c'].
  - A slice object with labels, e.g. 'a':'f'. (Note that contrary to usual python slices, **both** the start and the stop are included)
  - A boolean array of the same length as the axis being sliced, e.g. [True, False, True].

- Note, in the titanic dataset we use an **integer index** but the value passed to loc could also be a **String** index if applicable.

Using loc

- **Rows** can be retrieved via an index label value using **.loc[]** on an entire dataframe
- It is important to understand that when we access df.loc[0] below it looks for the matching label (it doesn't just return the row with position 0)
- Below we can access multiple row directly by pass loc[] a list of row labels we want returned. (Single row is returned as a Series, two or more rows is returned as a dataframe)

```
import pandas as pd

df = pd.read_csv("titanic.csv")


print ( df.loc[0] )

print (df.loc[  [1, 20] ])
```

```
PassengerId                          1
Survived                             0
Pclass                               3
Name           Braund, Mr. Owen Harris
Sex                               male
Age                                 22
SibSp                                1
Parch                                0
Ticket                       A/5 21171
Fare                              7.25
Cabin                              NaN
Embarked                             S
Name: 0, dtype: object
```

PassengerId	Survived	Pclass	...	Fare	Cabin	Embarked
1	2	1	1	...	71.2833	C85	C
20	21	0	2	...	26.0000	NaN	S

Using loc on a DataFrame

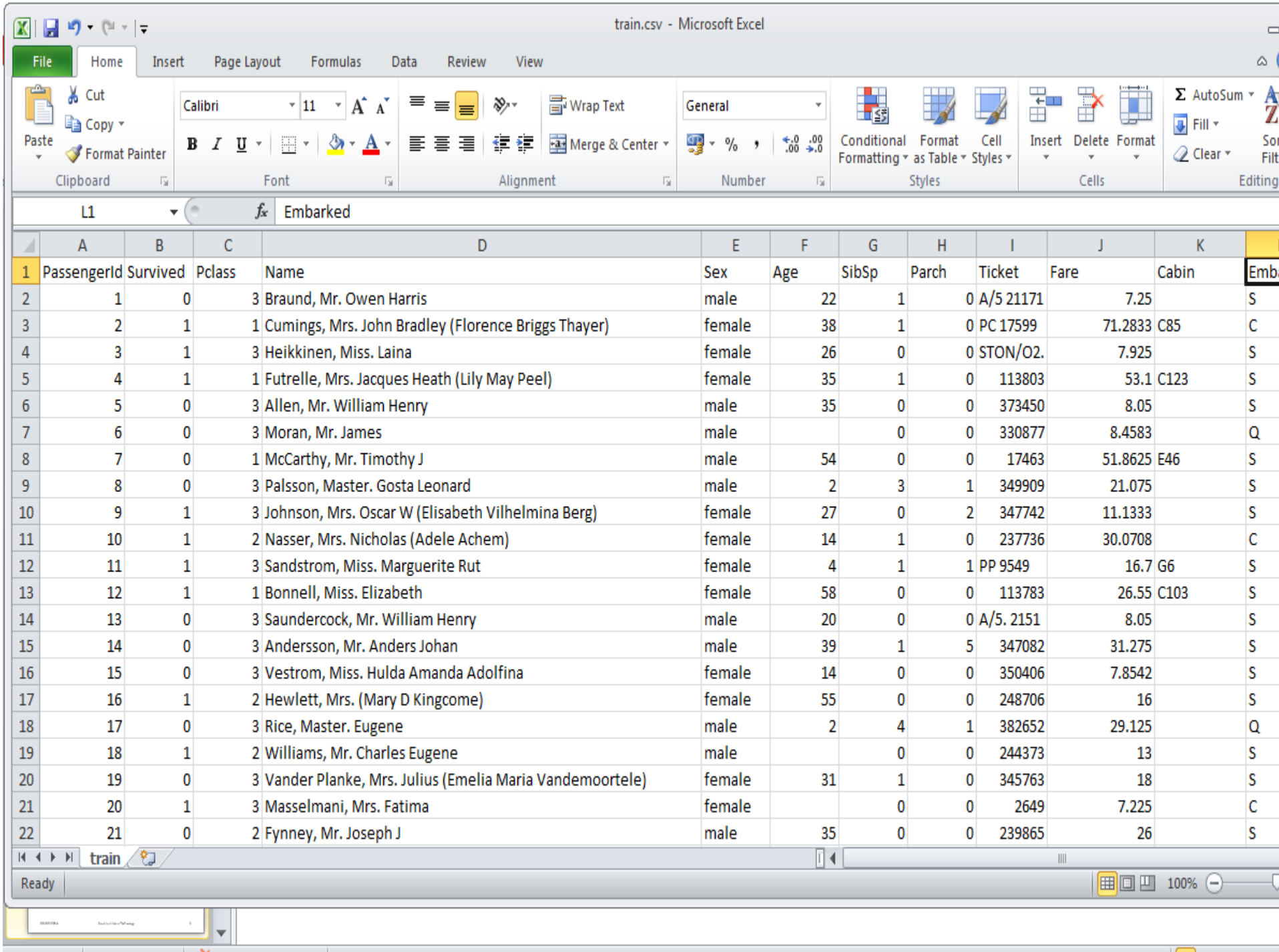
- To properly illustrate the use of loc on a DataFrame when we read in the DataFrame we index it using the name column as shown below (previously it Pandas automatically generated an integer based index starting at 0)

```
import pandas as pd

df = pd.read_csv("titanic.csv", index_col='Name')

print (df["Fare"])
```

```
Name
Braund, Mr. Owen Harris                                7.2500
Cumings, Mrs. John Bradley (Florence Briggs Thayer)   71.2833
Heikkinen, Miss. Laina                                 7.9250
Futrelle, Mrs. Jacques Heath (Lily May Peel)          53.1000
Allen, Mr. William Henry                               8.0500
Moran, Mr. James                                       8.4583
McCarthy, Mr. Timothy J                               51.8625
Palsson, Master. Gosta Leonard                        21.0750
Johnson, Mrs. Oscar W (Elisabeth Vilhelmina Berg)     11.1333
Nasser, Mrs. Nicholas (Adele Achem)                   30.0708
Sandstrom, Miss. Marguerite Rut                       16.7000
Bonnell, Miss. Elizabeth                              26.5500
Saundercock, Mr. William Henry                         8.0500
Andersson, Mr. Anders Johan                           31.2750
Vestrom, Miss. Hulda Amanda Adolfina                   7.8542
Hewlett, Mrs. (Mary D Kingcome)                       16.0000
Rice, Master. Eugene                                  29.1250
```



	A	B	C	D	E	F	G	H	I	J	K	
1	PassengerId	Survived	Pclass	Name	Sex	Age	SibSp	Parch	Ticket	Fare	Cabin	Emb
2	1	0	3	Braund, Mr. Owen Harris	male	22	1	0	A/5 21171	7.25		S
3	2	1	1	Cumings, Mrs. John Bradley (Florence Briggs Thayer)	female	38	1	0	PC 17599	71.2833	C85	C
4	3	1	3	Heikkinen, Miss. Laina	female	26	0	0	STON/O2.	7.925		S
5	4	1	1	Futrelle, Mrs. Jacques Heath (Lily May Peel)	female	35	1	0	113803	53.1	C123	S
6	5	0	3	Allen, Mr. William Henry	male	35	0	0	373450	8.05		S
7	6	0	3	Moran, Mr. James	male		0	0	330877	8.4583		Q
8	7	0	1	McCarthy, Mr. Timothy J	male	54	0	0	17463	51.8625	E46	S
9	8	0	3	Palsson, Master. Gosta Leonard	male	2	3	1	349909	21.075		S
10	9	1	3	Johnson, Mrs. Oscar W (Elisabeth Vilhelmina Berg)	female	27	0	2	347742	11.1333		S
11	10	1	2	Nasser, Mrs. Nicholas (Adele Achem)	female	14	1	0	237736	30.0708		C
12	11	1	3	Sandstrom, Miss. Marguerite Rut	female	4	1	1	PP 9549	16.7	G6	S
13	12	1	1	Bonnell, Miss. Elizabeth	female	58	0	0	113783	26.55	C103	S
14	13	0	3	Saundercock, Mr. William Henry	male	20	0	0	A/5. 2151	8.05		S
15	14	0	3	Andersson, Mr. Anders Johan	male	39	1	5	347082	31.275		S
16	15	0	3	Vestrom, Miss. Hulda Amanda Adolfina	female	14	0	0	350406	7.8542		S
17	16	1	2	Hewlett, Mrs. (Mary D Kingcome)	female	55	0	0	248706	16		S
18	17	0	3	Rice, Master. Eugene	male	2	4	1	382652	29.125		Q
19	18	1	2	Williams, Mr. Charles Eugene	male		0	0	244373	13		S
20	19	0	3	Vander Planke, Mrs. Julius (Emelia Maria Vandemoortele)	female	31	1	0	345763	18		S
21	20	1	3	Masselmani, Mrs. Fatima	female		0	0	2649	7.225		C
22	21	0	2	Fynney, Mr. Joseph J	male	35	0	0	239865	26		S

Using loc on a DataFrame

- To properly illustrate the use of loc on a DataFrame when I read in the DataFrame I index is using the name column as shown below

```
df = pd.read_csv("titanic.csv", index_col='Name')

print (df.loc[ "Moran, Mr. James“ ])

print (df.loc[ "Moran, Mr. James": "Bonnell, Miss. Elizabeth“ ])
```

Using loc on a DataFrame

- To properly illustrate the use of loc on a DataFrame when I read in the DataFrame I index is using the name column as shown below

```
df = pd.read_csv("titanic.csv", index_col='Name')

print (df.loc[ "Moran, Mr. James“ ])

print (df.loc[ "Moran, Mr. James": "Bonnell, Miss. Elizabeth“ ])
```

```
PassengerId          6
Survived             0
Pclass               3
Sex               male
Age                NaN
SibSp                0
Parch                0
Ticket          330877
Fare            8.4583
Cabin              NaN
Embarked             Q
Name: Moran, Mr. James, dtype: object
```

Using loc on a DataFrame

- To properly illustrat
  DataFrame I index i

```
df = pd.read_csv("tit

print (df.loc[ "Moran

print (df.loc[ "Moran, Mr. James": "Bonnell, Miss. Elizabeth“ ])
```

Name	PassengerId	Survived	\
Moran, Mr. James	6	0	
McCarthy, Mr. Timothy J	7	0	
Palsson, Master. Gosta Leonard	8	0	
Johnson, Mrs. Oscar W (Elisabeth Vilhelmina Berg)	9	1	
Nasser, Mrs. Nicholas (Adele Achem)	10	1	
Sandstrom, Miss. Marguerite Rut	11	1	
Bonnell, Miss. Elizabeth	12	1	

Name	Pclass	Sex	Age	\
Moran, Mr. James	3	male	NaN	
McCarthy, Mr. Timothy J	1	male	54.0	
Palsson, Master. Gosta Leonard	3	male	2.0	
Johnson, Mrs. Oscar W (Elisabeth Vilhelmina Berg)	3	female	27.0	
Nasser, Mrs. Nicholas (Adele Achem)	2	female	14.0	
Sandstrom, Miss. Marguerite Rut	3	female	4.0	
Bonnell, Miss. Elizabeth	1	female	58.0	

Name	SibSp	Parch	Ticket	\
Moran, Mr. James	0	0	330877	
McCarthy, Mr. Timothy J	0	0	17463	

Selecting DataFrame rows and columns simultaneously - loc

Up to now we have used loc to extract entire rows, here we exact and rows and selected columns

```
import pandas as pd

df = pd.read_csv("titanic.csv", index_col='Name')

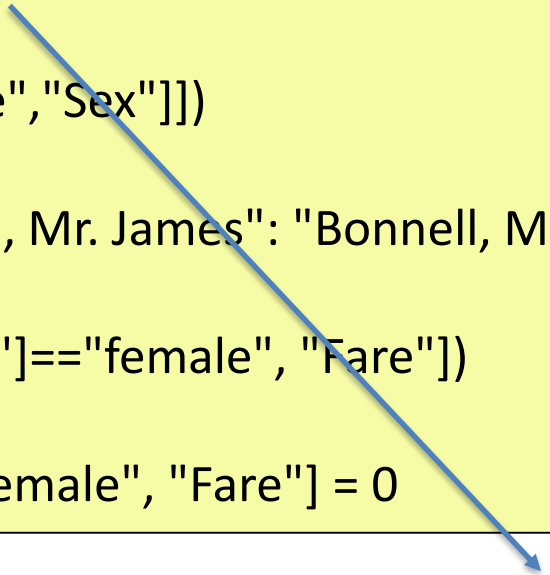
print (df.loc["Moran, Mr. James", "Fare"])

print (df.loc[:, ["Fare","Sex"]])

print (df.loc["Moran, Mr. James": "Bonnell, Miss. Elizabeth", ["Fare","Sex"]])

print (df.loc[df["Sex"]=="female", "Fare"])

df.loc[df["Sex"]=="female", "Fare"] = 0
```



Retrieves the row indexed “Moran, Mr. James", and the column “Fare”, which returns the value 8.4583

Selecting DataFrame rows and columns simultaneously - loc

```
import pandas as pd

df = pd.read_csv("titanic.csv", index_col='Name')

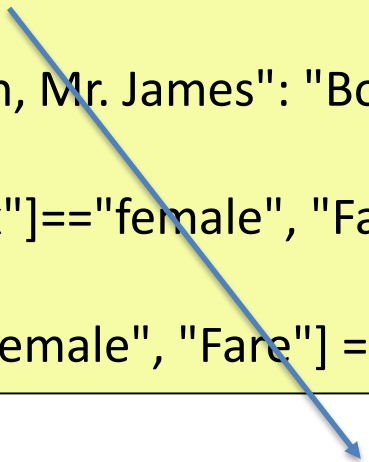
print (df.loc["Moran, Mr. James", "Fare"])

print (df.loc[:, ["Fare","Sex"]])

print (df.loc["Moran, Mr. James": "Bonnell, Miss. Elizabeth", ["Fare","Sex"]])

print (df.loc[df["Sex"]=="female", "Fare"])

df.loc[df["Sex"]=="female", "Fare"] = 0
```



Accesses all rows but just the columns Fare and Sex

Selecting DataFrame rows and columns simultaneously - loc

```
import pandas as pd

df = pd.read_csv("titanic.csv", index_col='Name')

print (df.loc["Moran, Mr. James", "Fare"])

print (df.loc[:, ["Fare","Sex"]])

print (df.loc["Moran, Mr. James": "Bonnell, Miss. Elizabeth", ["Fare","Sex"]])

print (df.loc[df["Sex"]=="female", "Fare"])

df.loc[df["Sex"]=="female", "Fare"] = 0
```

Retrieves row starting from the index Moran, Mr. James up to an including the index Bonnell, Miss. Elizabeth but just the columns Fare and Sex

Selecting DataFrame rows and columns simultaneously - loc

```
import pandas as pd

df = pd.read_csv("titanic.csv", index_col='Name')

print (df.loc["Moran, Mr. James", "Fare"])

print (df.loc[:, ["Fare","Sex"]])

print (df.loc["Moran, Mr. James": "Bonnell, Miss. Elizabeth", ["Fare","Sex"]])

print (df.loc[df["Sex"]=="female", "Fare"])

df.loc[df["Sex"]=="female", "Fare"] = 0
```

This will return the Fare column for all row that have Sex == female

Selecting DataFrame rows and columns simultaneously - loc

```
import pandas as pd

df = pd.read_csv("titanic.csv", index_col='Name')

print (df.loc["Moran, Mr. James", "Fare"])

print (df.loc[:, ["Fare","Sex"]])

print (df.loc["Moran, Mr. James": "Bonnell, Miss. Elizabeth", ["Fare","Sex"]])

print (df.loc[df["Sex"]=="female", "Fare"])

df.loc[df["Sex"]=="female", "Fare"] = 0
```

This will set the Fare value for all female passengers to 0

Using iloc on a DataFrame

- We can also access specific rows using the iloc function.
- Again we specify an integer positional index (not label) and it returns the corresponding row.
- Allowed inputs are:
  - An integer, e.g. 5.
  - A list or array of integers, e.g. [4, 3, 0].
  - A slice object with ints, e.g. 1:7.
  - A Boolean array.

Using iloc on a DataFrame

```
import pandas as pd

df = pd.read_csv("titanic.csv")

# prints the entire first row
#(returned as a Series object)
print ( df.iloc[ 0 ] )

# selects the row with index 1
#and 3 (DataFrame obj)
print ( df.iloc[ [1, 3] ] )

# prints the index 4, 7 and 10
print ( df.iloc[ 4:11:3 ] )
```

```
PassengerId                            1
Survived                               0
Pclass                                 3
Name           Braund, Mr. Owen Harris
Sex                               male
Age                                 22
SibSp                                1
Parch                                0
Ticket                       A/5 21171
Fare                              7.25
Cabin                              NaN
Embarked                             S
Name: 0, dtype: object
```

	PassengerId	Survived	Pclass	...	Fare	Cabin	Embarked
1	2		1	...	71.2833	C85	C
3	4	1	1	...	53.1000	C123	S

[2 rows x 12 columns]

Using iloc on a DataFrame

```
import pandas as pd

df = pd.read_csv("titanic.

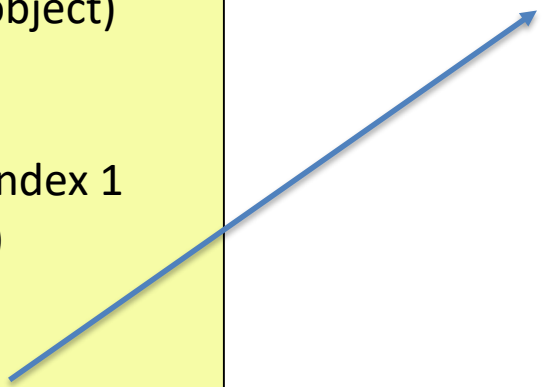
# prints the entire first ro
#(returned as a Series object)
print (df.iloc[0])

# selects the row with index 1
#and 3 (DataFrame obj)
print (df.iloc[[1, 3]])

# prints the index 4, 7 and 10
print (df.iloc[4:11:3])
```

```
    PassengerId  Survived  Pclass                                Name     Sex  \
4             5         0       3         Allen, Mr. William Henry    male
7             8         0       3   Palsson, Master. Gosta Leonard    male
10           11         1       3  Sandstrom, Miss. Marguerite Rut  female

     Age  SibSp  Parch    Ticket    Fare Cabin Embarked
4   35.0      0      0    373450   8.050   NaN        S
7    2.0      3      1    349909  21.075   NaN        S
10   4.0      1      1  PP 9549  16.700    G6        S
```



Selecting DataFrame rows and columns simultaneously - iloc

- The method of using iloc is similar to how we selected data in NumPy
- The syntax is data.iloc[<row selection>, <column selection>]

```
print (df.iloc[:, 0])

print ( df.iloc[:, 0:3])

print ( df.iloc[:, [0,3]])
```

1. Print out the first column (Series object)
2. Print out the first, second and third column (DataFrame Object)
3. Print out the first and fourth columns (DataFrame Object)

Selecting DataFrame rows and columns simultaneously - iloc

- When using a Boolean masking with loc it supports either a Boolean Series object or Boolean array. In contrast iloc only support Boolean array so you will have to convert the Boolean Series into an array using to_numpy()

```
import pandas as pd

df = pd.read_csv("titanic.csv",
index_col='Name')



bool_series = df["Sex"]=="female"

print (df.iloc[bool_series.to_numpy(), 2])
```

Counting – value_counts()

- A very useful method **value_counts()** can be used to count the **number of occurrences of each entry** in a column (it returns a Series object)

- It presents the results in **descending** order
- For examples, how many males and females are represented in dataset

```
df = pd.read_csv("titanic.csv")
print (df['Sex'].value_counts())
```

```
male      577
female    314
dtype: int64
```

Example 1

- Read data in from the titanic dataset and determine the four most common ages represented.

```
df = read_csv("titanic.csv")
freqAges = df['Age']
print (freqAges.value_counts().head(4))
```

```
24.0    30
22.0    27
18.0    26
19.0    25
Name: Age, dtype: int64
```

Missing Values

- It is common in real-world applications that some features are missing one or more values for various reasons. There could be an **error in the data collection process**, certain fields may have been **left blank in a survey**, **power outage**, etc.

- The following will return the number of missing NaN values in in each column of your dataframe.

- **df.isnull().sum()**

```
import pandas as pd

seriesA = pd.Series( ['Jim', 'Jean', 'Ted', 'Elizabeth'] )
seriesB = pd.Series( ['H1', 'H2.1', 'H1'] )
seriesC = pd.Series( ['BSc', 'MSc', 'PhD', 'BSc'] )


 # Define a dictionary containing Students data
data = {'Name': seriesA,
       'Grade': seriesB,
       'Qualification': seriesC}

df = pd.DataFrame(data)
print (df)
print (df.isnull().sum())
```

```
     Name Grade Qualification
0      Jim    H1           BSc
1     Jean  H2.1           MSc
2      Ted    H1           PhD
3  Elizabeth  NaN           BSc

Name           0
Grade          1
Qualification  0
dtype: int64
```

Dealing with Missing Values - Removal

- One of the easiest ways to deal with missing values is to simply remove the corresponding features (columns) or rows from the dataset entirely.
  - **Rows**
    - **df.dropna()** will remove any rows that contain a missing value.
    - **df.dropna(subset=['A'])** only drop rows where missing values appear in a specific column in this case column A.
    - **df.dropna(thresh=3)** the parameter thresh specifies the number of non-NAN values (non missing values) that a row must have in order to be retained.
  - **Columns**
    - **df.dropna(axis = 1)** will drop **columns** that have at least one missing value
    - if you want to drop a column of a specific name you can call **df.drop(['ColumnName'], axis=1)**

- Each off the above will return a separate copy of the dataset with the new changes (if you want the changes to take place on the current dataframe then you can se the parameter **inplace=True**)

Missing Values

```
import pandas as pd


seriesA = pd.Series( ['Jim', 'Jean', 'Ted', 'Elizabeth'] )
seriesB = pd.Series( ['H1', 'H2.1', 'H1'] )
seriesC = pd.Series( ['BSc', 'MSc', 'PhD', 'BSc'] )


  # Define a dictionary containing Students data
data = {'Name': seriesA,
        'Grade': seriesB,
        'Qualification': seriesC}

df = pd.DataFrame(data)
df.dropna(inplace=True)
print (df)
```

	Name	Grade	Qualification
0	Jim	H1	BSc
1	Jean	H2.1	MSc
2	Ted	H1	PhD

Adding and Deleting Entire Columns

```
import pandas as pd

  # Define a dictionary containing Students data
data = {'Name': ['Jim', 'Jean', 'Ted', 'Elizabeth'],
        'Grade': ['H1', 'H2.1', 'Pass', 'H1'],
        'Qualification': ['BSc', 'MSc', 'PhD', 'BSc']}

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

age = [21, 34, 34, 53]

df["Age"] = age
print (df)

df.drop(["Qualification", "Grade"], axis = 1, inplace = True)
print (df)
```

	Name	Grade	Qualification
0	Jim	H1	BSc
1	Jean	H2.1	MSc
2	Ted	Pass	PhD
3	Elizabeth	H1	BSc

Adding and Deleting Columns

```
import pandas as pd

  # Define a dictionary containing Students data
data = {'Name': ['Jim', 'Jean', 'Ted', 'Elizabeth'],
        'Grade': ['H1', 'H2.1', 'Pass', 'H1'],
        'Qualification': ['BSc', 'MSc', 'PhD', 'BSc']}

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

age = [21, 34, 34, 53]

df["Age"] = age
print (df)

df.drop(["Qualification", "Grade"], axis = 1, inplace = True)
print (df)
```

	Name	Grade	Qualification	Age
0	Jim	H1	BSc	21
1	Jean	H2.1	MSc	34
2	Ted	Pass	PhD	34
3	Elizabeth	H1	BSc	53

Adding and Deleting Columns

```
import pandas as pd

  # Define a dictionary containing Students data
data = {'Name': ['Jim', 'Jean', 'Ted', 'Elizabeth'],
        'Grade': ['H1', 'H2.1', 'Pass', 'H1'],
        'Qualification': ['BSc', 'MSc', 'PhD', 'BSc']}

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

age = [21, 34, 34, 53]

df["Age"] = age
print (df)

df.drop(["Qualification", "Grade"], axis = 1, inplace = True)
print (df)
```

	Name	Age
0	Jim	21
1	Jean	34
2	Ted	34
3	Elizabeth	53

Summary

- NumPy 2D Arrays
  - [row, column] access
  - Slice operations [start:stop:step]
  - Performing operations of a specific axis (np.sum(arr1, axis = 0))
  - Comparison Operators
  - Advanced Index (Boolean index with comparison operation, interger list)
  - Logical Operators

- Pandas
  - Series and DataFrame
  - Accessing Columns
  - Using label based indexing (loc) and integer based indexing (iloc)