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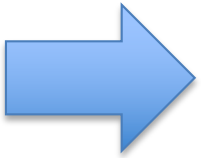
Introduction to Pandas (with additional examples)

Contents



Introduction to Pandas Series and Dataframe data structures.

- Reading data into a Dataframe
- Accessing Data from a Dataframe
- Merging and Grouping Data

Pandas

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

- Fortunately, when dealing with complex data we can use the **Python Data Analysis Library** (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
  - http://pandas.pydata.org/pandas-docs/version/0.13.1/pandas.pdf

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

```
import numpy as np
import pandas as pd

s1 = pd.Series(np.random.randn(5))
s2 = pd.Series(np.random.randn(5), index=['a','b','c','d','e'])
# number of indices must match number of data points

print (s1)
print (s2)
```

```
0    0.275735
1   -0.445412
2    0.163060
3   -0.364863
4   -0.069800
dtype: float64

a    0.068250
b    0.455478
c    1.356175
d    0.484393
e   -0.919080
dtype: float64
```

```
import pandas as pd

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

# if you pass a dictionary to a series, the keys becomes the
indices of the Series
cities = pd.Series(d)

print (cities)
```

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

Series

- You can use the **index to select specific items** from the Series.
  - The first print will print the entire series
  - The second will print the item associated with index ‘b’ (note you can access one item at time using this method)
  - The third uses **double square brackets** and prints a subset of the original series (**note it returns a independent Series object**)

```
s1 = pd.Series([1, 2, 3, 4, 5], index=['a','b','c','d','e'])

print (s1)

print (s1['b'])

print (s1[['a', 'b']])
```

```
a    1
b    2
c    3
d    4
e    5
dtype: int64

2

a    1
b    2
dtype: int64
```

Series

- Another useful feature of a series is using boolean conditions
  - **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]))
```

As with NumPy, relational operators return 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'>
```

Series

- It is also very easy to change a value within a series.

```
d = {'Dublin': 245, 'Cork': 150, 'Limerick': 125, 'Galway': 360, 'Belfast': 300}
irishCities = pd.Series(d)

print (irishCities)

irishCities["Cork"] = 180
irishCities["Kilkenny"] = 120

print (irishCities)
```

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

Galway     360
Belfast    300
Cork       180
Dublin     245
Limerick   125
Kilkenny   120
dtype: int64
```

Similar to the syntax we use for adding a key value pair to a dictionary.

Series

- What does the code below achieve?

```
d = {'Dublin': 245, 'Cork': 150, 'Limerick': 125, 'Galway': 360, 'Belfast': 300}
irishCities = pd.Series(d)

print (irishCities)

irishCities[irishCities<160] = 100

print (irishCities)
```

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


Galway     360
Belfast    300
Cork       100
Dublin     245
Limerick   100
dtype: int64
```

This code will go through the Series setting any value that is currently less than 160 to a value of 100.
When you use Boolean selection coupled with assignment it selects the entries in the existing Series object to be changed.

Series

- Normal NumPy mathematical operations can be completed on Series objects as well.

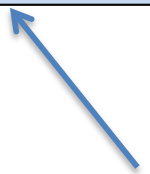
```
d = {'Dublin': 245, 'Cork': 150, 'Limerick': 125, 'Galway': 360, 'Belfast':
300}
irishCities = pd.Series(d)

print (irishCities*100)

print (np.square(irishCities))
```

```
Belfast     30000
Cork        15000
Dublin      24500
Galway      36000
Limerick    12500
dtype: int64

Belfast     90000
Cork        22500
Dublin      60025
Galway      129600
Limerick    15625
dtype: int64
```



Notice in this example we still use NumPys square method but rather than passing it a NumPy array we pass it a Series instead

Series – len and unique function

- As with all data structures we have seen so far we can use the ***len()*** function to obtain the number of values stored in a Series (this also works for a dataframe, which return the number of rows)

- Another useful function to use with a Series object is the ***unique*** function, which returns all the unique data items in a specific series object (it is returned as a NumPy array).

```
import pandas as pd


seriesA = pd.Series(['A', 'C', 'B', 'B', 'A'])

print (pd.unique(seriesA))
```

```
['A' 'C' 'B']
```

Example

- Create a Pandas Series variable to store the data depicted in the table below (we will use the names as indices and the grades as the values).
- Write code that will return a Series containing all those that failed the exam.
- Next write code that will increase any grade less than 40 by 5%

Name	Grade
Jim	78
Elaine	23
Ted	65
Frank	88
Sarah	80
Tim	33

Example

```
import pandas as pd

studentDetails = {'Jim':78, 'Elaine':23, 'Ted':65, 'Frank':88, 'Sarah':80, 'Tim':33}
grades = pd.Series(studentDetails)

print grades[grades<40]


grades[grades<40] += 5

print (grades)
```

```
Elaine    23
Tim       33
dtype: int64

Elaine    28
Frank     88
Jim       78
Sarah     80
Ted       65
Tim       38
dtype: int64
```

It is possible to turn this Series into a one-column DataFrame with the to_frame method.
This method will use the Series name as the new column name:

```
>>> director.to_frame()
```

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

- To create a DataFrame out of common Python data structures, we can pass a dictionary of lists to the DataFrame constructor.
- We can also easily create a dataframe by passing it a 2D NumPy array.

- 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

```
import pandas as pd

data = {'student': ['Jim Murphy', 'Ted Scully', 'Jason Oakley', 'Pat OBrien'],
        'grade': [67, 75, 56, 89],
        'department': ["Computing", "Chemistry", "Biology", "Maths"]}

students = pd.DataFrame(data)

print students
```

```
 department  grade       student
0  Computing     67    Jim Murphy
1  Chemistry     75    Ted Scully
2    Biology     56  Jason Oakley
3      Maths     89    Pat OBrien
```

Notice the **key becomes the columns headers** of the dataframe and the values of the dictionary (the list) populate the column.

Creating a DataFrame

```
import pandas as pd
data = {'student': ['Jim Murphy', 'Ted Scully', 'Jason Oakley', 'Pat OBrien'],
        'grade': [67, 75, 56, 89],
        'department': ["Computing", "Chemistry", "Biology", "Maths"]}

students = pd.DataFrame(data, columns=['student', 'grade', 'department'])

print students
```

```
       student    grade   department
0    Jim Murphy     67  Computing
1    Ted Scully     75     Chemistry
2  Jason Oakley     56    Biology
3    Pat OBrien     89      Maths
```

I can directly specify the names of the columns and the order in which they appear by including a columns argument when creating the dataframe. It is important that the names of the columns match the dictionary keys

Creating a DataFrame

- Rather than using a list as we did in the previous slide we can also create a dataframe by passing a dictionary 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

Creating a Dataframe

- In the example below we can easily 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
```

Creating a Dataframe

- We can also specify column names when creating the dataframe.

```
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, columns=['colA', 'colB', 'colC'])
print
print df
```

	colA	colB	colC
0	1	2	3
1	4	5	6
2	7	8	9

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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

- On April 15, 1912, during her maiden voyage, the Titanic sank after colliding with an iceberg, killing 1502 out of 2224 passengers and crew.

- Although there was some element of luck involved in surviving the sinking, some **groups of people were more likely to survive than others**, such as women, children, and the first-class passengers.

- The dataset we examine contains the details of **891 passengers aboard the titanic**. We will use this as an introduction to the Pandas library.

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

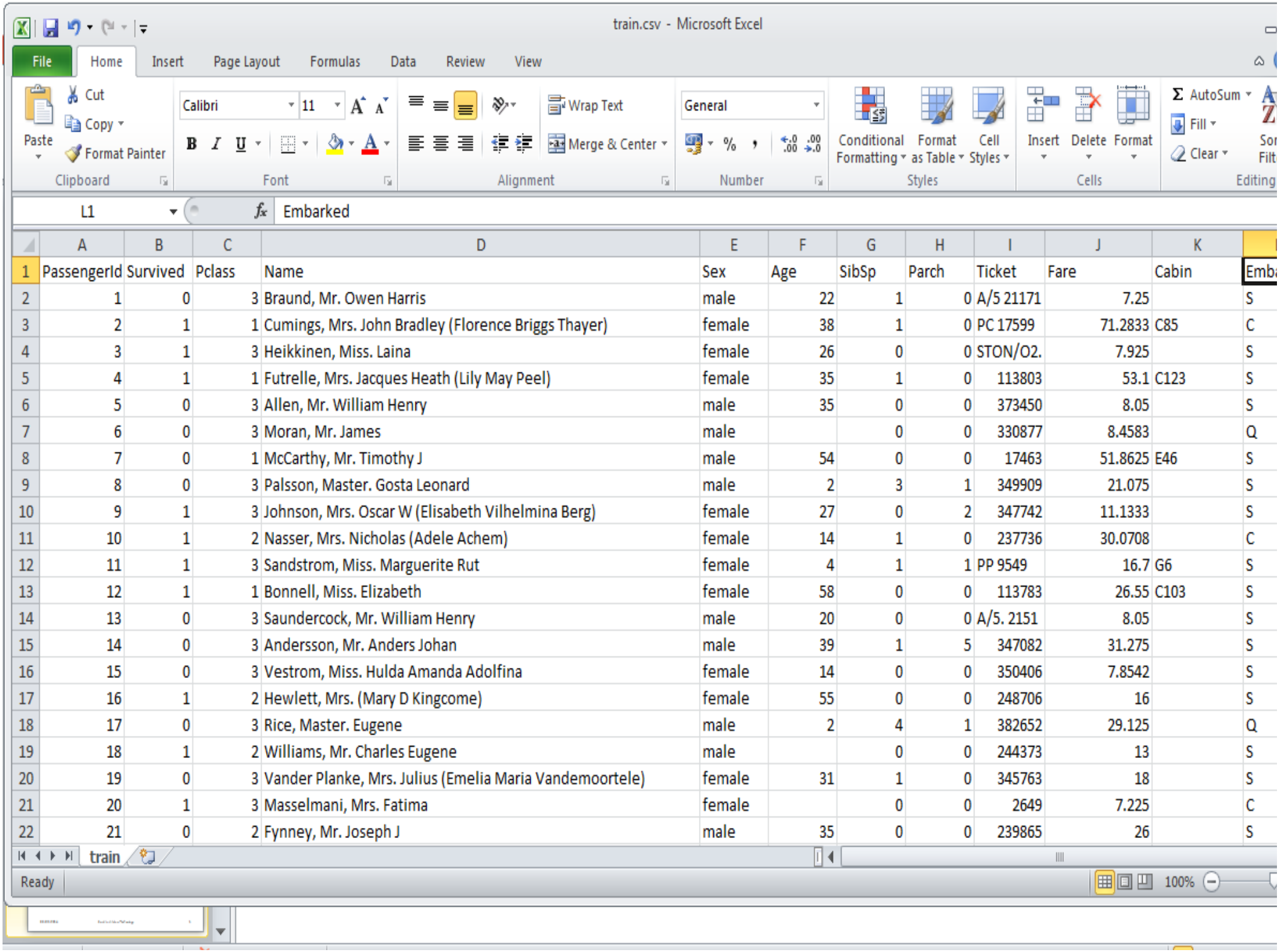
parch Number of Parents/Children Aboard

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	L
1	PassengerId	Survived	Pclass	Name	Sex	Age	SibSp	Parch	Ticket	Fare	Cabin	Emba
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

Reading Data from a File

- To pull in the text file, we will use the pandas function *read_csv* method. Let us take a look at this function and what inputs it takes.
- The read_csv has a very large number of parameters such as specifying the delimiter, included headers, etc

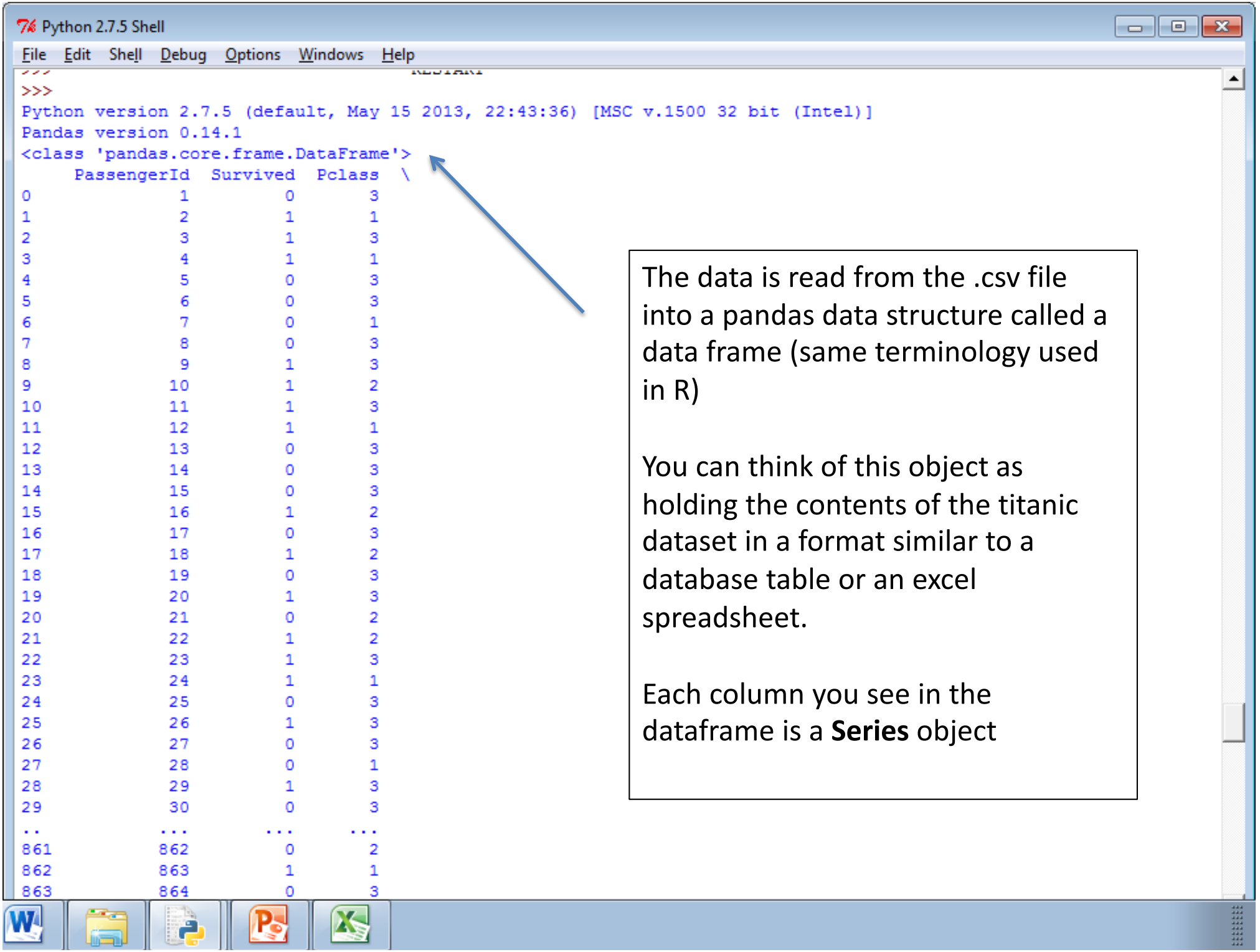
```
# General syntax to import specific functions in a library:
Import pandas as pd

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

print type(df)

print df
```

http://pandas.pydata.org/pandas-docs/stable/generated/pandas.read_csv.html



The data is read from the .csv file into a pandas data structure called a data frame (same terminology used in R)

You can think of this object as holding the contents of the titanic dataset in a format similar to a database table or an excel spreadsheet.

Each column you see in the dataframe is a **Series** object

Describing a DataFrame

- DataFrame's have a very useful **describe** method, which is used for seeing **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

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Accessing Column Data

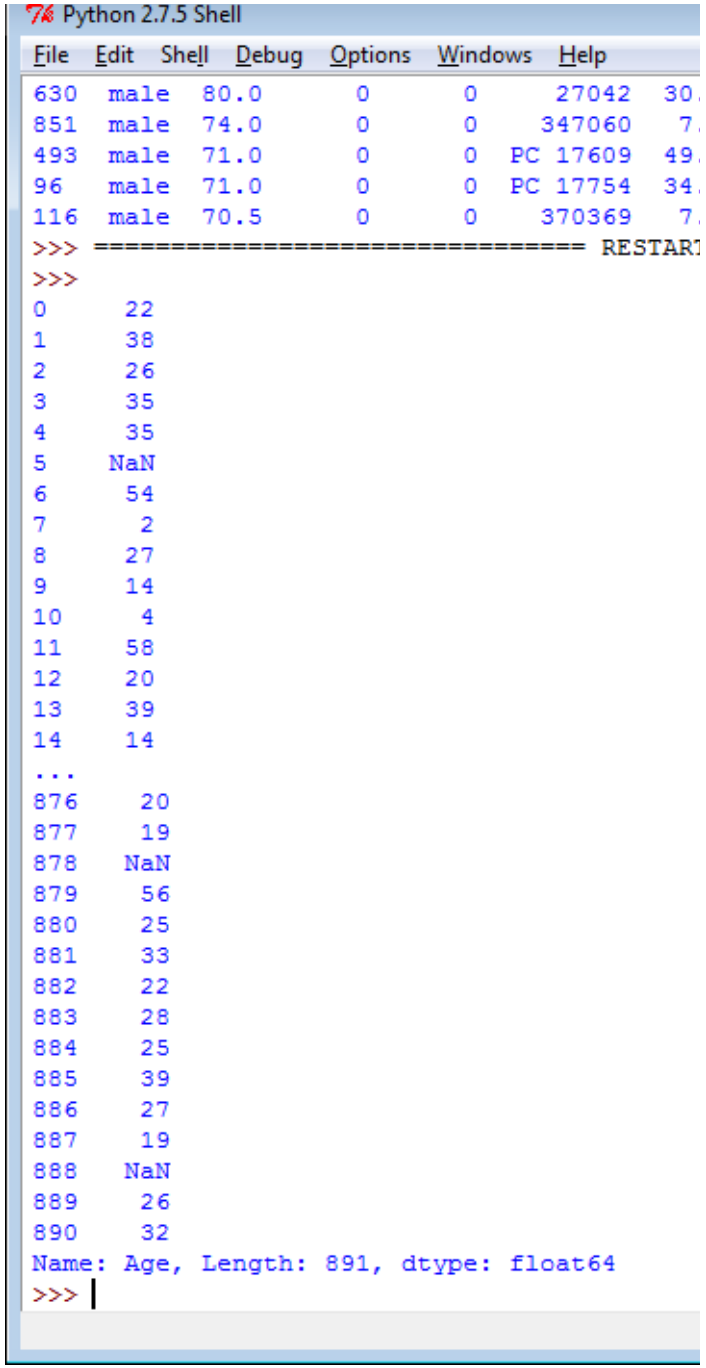
- To select a column, we index with the name of the column:
- **dataframe[‘columnName’]**

```
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.



Accessing Row Data

- To get the first 5 rows of a dataframe, we can use a slice: df[0:5] or df[:5].

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

firstEntries = df[:5]

print firstEntries
```

As with NumPy a slice **returns a view** of the original data.

Any changes made to view will be reflected in the original dataframe

```
   PassengerId  Survived  Pclass  \
0            1         0       3
1            2         1       1
2            3         1       3
3            4         1       1
4            5         0       3

                                                Name     Sex  Age  SibSp  \
0                            Braund, Mr. Owen Harris    male   22      1
1  Cumings, Mrs. John Bradley (Florence Briggs Th...  female   38      1
2                             Heikkinen, Miss. Laina  female   26      0
3       Futrelle, Mrs. Jacques Heath (Lily May Peel)  female   35      1
4                           Allen, Mr. William Henry    male   35      0

   Parch            Ticket     Fare Cabin Embarked
0      0         A/5 21171   7.2500   NaN        S
1      0          PC 17599  71.2833   C85        C
2      0  STON/O2. 3101282   7.9250   NaN        S
3      0            113803  53.1000  C123        S
4      0            373450   8.0500   NaN        S
```

Accessing Rows and Individual Data Items

- We can combine the techniques we saw in the previous slides in order to get the first 10 rows of a specific column (age in this case):

```
df = pd.read_csv("titanic.csv")
print df['Age'][:10]
```

```
>>>
0     22
1     38
2     26
3     35
4     35
5    NaN
6     54
7      2
8     27
9     14
Name: Age, dtype: float64
```

To access a specific data item within a data frame we can use the following **df[‘columnName’][rowNumber]**

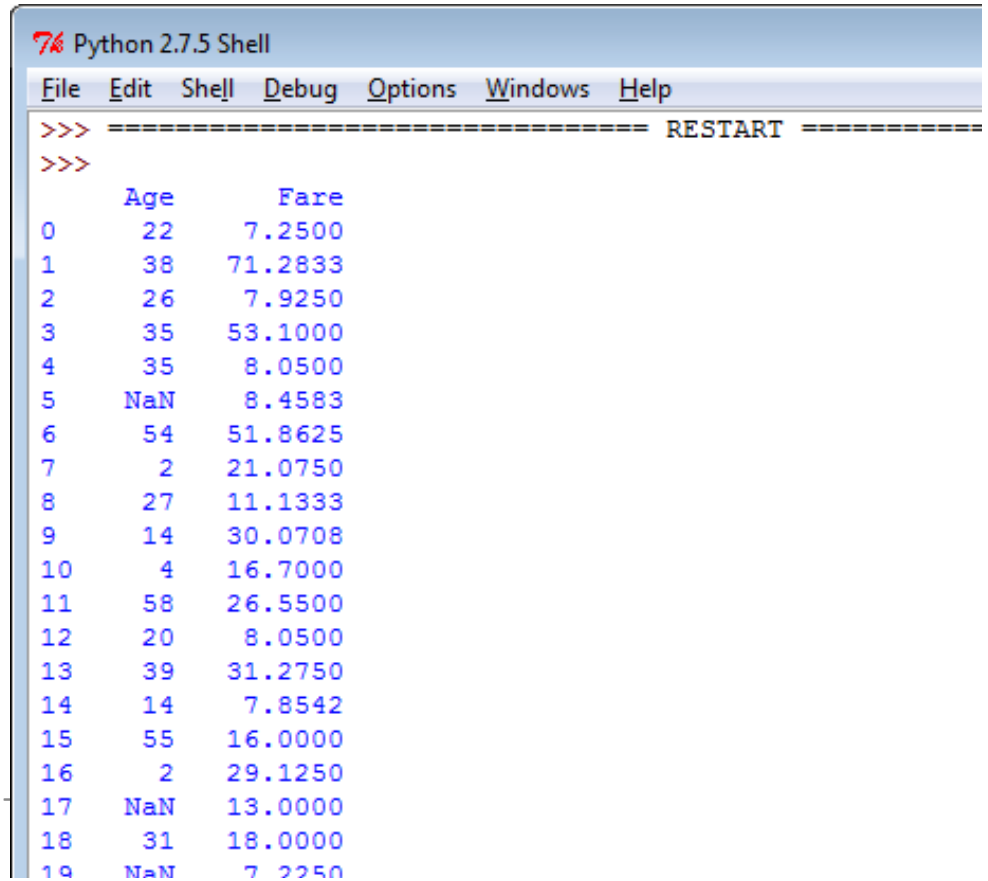
```
df = pd.read_csv("titanic.csv")
print df['Age'][11]
```

```
>>>
58.0
>>>
```

Selecting Multiple Columns

- Pandas makes it really easy to select a subset of the columns: just index which list of columns you want.
- Note this returns another dataframe
  - (note the **double square brackets**)

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



Accessing Column (Series) Data

- 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 datatype 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
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)
```

Accessing Data - .head and .tail

- It is important to understand that if you **extract a column** from a dataframe you are working with a **view of the same data**.
- Both the dataframe and the column you have extracted refer to the same data.
- In the example below you will see that the change made to allAges will be reflected in the dataframe age column.

```
import pandas as pd

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

print df['Age'].head(5)

allAges = df['Age']

allAges[0] = 877
print df['Age'].head(5)
```

```
0    22
1    38
2    26
3    35
4    35
Name: Age, dtype: float64
0    877
1     38
2     26
3     35
4     35
Name: Age, dtype: float64
```

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    30
22    27
18    26
28    25
dtype: int64
```

Performing Operations

- We can perform the same mathematical operations in Pandas as we could in NumPy

```
import pandas as pd

  df = pd.read_csv("titanic.csv")
  print "Average age", np.mean(df["Age"])

  print df["Age"].head(5)
  df["Age"] += 5

  print df["Age"].head(5)
```

```
Average age 29.6991176471
0    22
1    38
2    26
3    35
4    35
Name: Age, dtype: float64

0    27
1    43
2    31
3    40
4    40
Name: Age, dtype: float64
```

Querying the Dataset

- You can combine multiple queries within the [] after the dataset. Think of the square brackets as a way of refining the data you want.
- In the code we find the names of all those people that did not survive the sinking of the titanic

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

print df['Survived']==0

names = df['Name'][df['Survived']==0]
print names
```

```
0       True
1      False
2      False
3      False
4       True
5       True
6       True
7       True
8      False
9      False
10     False
11     False
12      True
13      True
14      True
...
876     True
877     True
878     True
```

```
0                                    Braund, Mr. Owen Harris
4                                   Allen, Mr. William Henry
5                                           Moran, Mr. James
6                                    McCarthy, Mr. Timothy J
7                             Palsson, Master. Gosta Leonard
12                           Saundercock, Mr. William Henry
13                              Andersson, Mr. Anders Johan
14                     Vestrom, Miss. Hulda Amanda Adolfina
16                                         Rice, Master. Eugene
18    Vander Planke, Mrs. Julius (Emelia Maria Vande...
20                                      Fynney, Mr. Joseph J
24                           Palsson, Miss. Torborg Danira
```

Exercise 2

- I want to determine the name and age of all those that died on the titanic that were under 10 years of age.

```
freqYoungAge = df[['Name', 'Age']][df['Survived']==0][df['Age']<10]
```

	Name	Age
7	Palsson, Master. Gosta Leonard	2
16	Rice, Master. Eugene	2
24	Palsson, Miss. Torborg Danira	8
50	Panula, Master. Juha Niilo	7
63	Skoog, Master. Harald	4
119	Andersson, Miss. Ellis Anna Maria	2
147	Ford, Miss. Robina Maggie "Ruby"	9
164	Panula, Master. Eino Viljami	1
171	Rice, Master. Arthur	4
182	Asplund, Master. Clarence Gustaf Hugo	9
205	Strom, Miss. Telma Matilda	2
278	Rice, Master. Eric	7
297	Allison, Miss. Helen Loraine	2
374	Palsson, Miss. Stina Viola	3
386	Goodwin, Master. Sidney Leonard	1
480	Goodwin, Master. Harold Victor	9
541	Andersson, Miss. Ingeborg Constanzia	9
634	Skoog, Miss. Mabel	9
642	Skoog, Miss. Margit Elizabeth	2
787	Rice, Master. George Hugh	8
813	Andersson, Miss. Ebba Iris Alfrida	6
824	Panula, Master. Urho Abraham	2
850	Andersson, Master. Sigvard Harald Elias	4
852	Boulos, Miss. Nourelain	9

Again if you were to print out the result of these two conditions it would be an array of booleans (as demonstrated in the previous slide). Only where the boolean entry is true for both survived and age will that row be selected from the dataset

Example

- In the following example I want to print the **number of males** and **females** that survived and those that didn't from each pclass.

```
import pandas as pd

def pClassSurvivorDetails(pClass, data):

    print "\nResults for Pclass =", pClass, "\n ------------------- “

    print "The following did not survive"
    notSurvive = df['Sex'][df['Survived']==0][df['Pclass']==pClass]
    print notSurvive.value_counts()

    print "The following did survive"
    survive = df['Sex'][df['Survived']==1][df['Pclass']==pClass]
    print survive.value_counts()



def main():
        df = pd.read_csv("titanic.csv")
        for value in [1, 2, 3]:
                pClassSurvivorDetails(value, df)
```

Results for Pclass = 1

The following did not survive
male 77
female 3
dtype: int64
The following did survive
female 91
male 45
dtype: int64

Results for Pclass = 2

The following did not survive
male 91
female 6
dtype: int64
The following did survive
female 70
male 17
dtype: int64

Results for Pclass = 3

The following did not survive
male 300
female 72
dtype: int64
The following did survive
female 72
male 47
dtype: int64

Combining Conditions using & and |

- It is also very useful to use **&** and **|** to combine conditions.
  - For example I want to search the data to return all cases that satisfy all of these conditions.
    - All those that have pclass =1
    - All those that boarded in Southampton
    - All those older than 20 years

```
pClass = df['Pclass']==1
sBoard = df['Embarked']=="S"
ages = df['Age']>20

print df[pClass & sBoard & ages]
```

Combining Conditions using & and |

- I can easily introduce an or connective by using | to link the various condition I use.

```
pClass = df['Pclass']==1
sBoard = df['Embarked']=="S"
ages = df['Age']>20

print df[["Pclass", "Embarked", "Age"]][pClass | sBoard | ages]
```

```
0     3     S  22
1     1     C  38
2     3     S  26
3     1     S  35
4     3     S  35
6     1     S  54
7     3     S   2
8     3     S  27
10    3     S   4
11    1     S  58
12    3     S  20
13    3     S  39
14    3     S  14
15    2     S  55
17    2     S  NaN
18    3     S  31
20    2     S  35
21    2     S  34
23    1     S  28  ……..
```

Converting Series to NumPy Array - .values

- We already mentioned that Dataframe is composed on multiple Series object.
- However, a Series object is internally a NumPy array.
- If you add values to the end of any Series, you'll get its internal numpy array
- We can also add .values to a dataframe to produce a 2D numpy array
- To do this you need to ensure there are only numerical contents in all columns

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

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

nAges = ages.values

print type(nAges)
```

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

<type 'numpy.ndarray'>
```

Example

- In this short program we will show the number of first, second and third class passengers that died when the titanic sunk.

```
bDeaths = df['Survived']==0
allDeaths = df[bDeaths]

print allDeaths['Pclass'].value_counts()
```

```
3    372
2     97
1     80
dtype: int64
```

Exercise

- Of course it might be more accurate to measure the number of 1, 2 and 3rd class passengers that died against the number of such passengers that boarded.

```
bDeaths = df['Survived']==0
allDeaths = df[bDeaths]

deathsFreq = allDeaths['Pclass'].value_counts()
allPassengers = df['Pclass'].value_counts()


print (deathsFreq*100)/ allPassengers )
```

```
1    37.037037
2    52.717391
3    75.763747
dtype: float64
```

Data Frame Analysis - Sorting

- The sort function is very useful. It's general syntax is
  - Sort(['Column1', 'Column2', …], ascending=[True, False, …])
- To sort the details of all passangers in terms of ascending age, we can sort the dataframe in ascending order

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

sorted = df.sort(['Age'], ascending=[False])

print sorted[:6]
```

Data Frame Analysis - Sorting

```
     PassengerId  Survived  Pclass                                      Name  \
630          631         1       1  Barkworth, Mr. Algernon Henry Wilson
851          852         0       3                      Svensson, Mr. Johan
493          494         0       1                   Artagaveytia, Mr. Ramon
96            97         0       1                 Goldschmidt, Mr. George B
116          117         0       3                    Connors, Mr. Patrick
672          673         0       2              Mitchell, Mr. Henry Michael

      Sex   Age  SibSp  Parch      Ticket     Fare Cabin Embarked
630  male  80.0      0      0       27042  30.0000   A23        S
851  male  74.0      0      0      347060   7.7750   NaN        S
493  male  71.0      0      0    PC 17609  49.5042   NaN        C
96   male  71.0      0      0    PC 17754  34.6542    A5        C
116  male  70.5      0      0      370369   7.7500   NaN        Q
672  male  70.0      0      0  C.A. 24580  10.5000   NaN        S
>>>
```

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Data Frame Analysis - Sorting

- If I wanted to sort the data in terms of ascending age and descending fare.

```
sorted = df.sort(['Age', 'Fare'], ascending=[True, False])
```

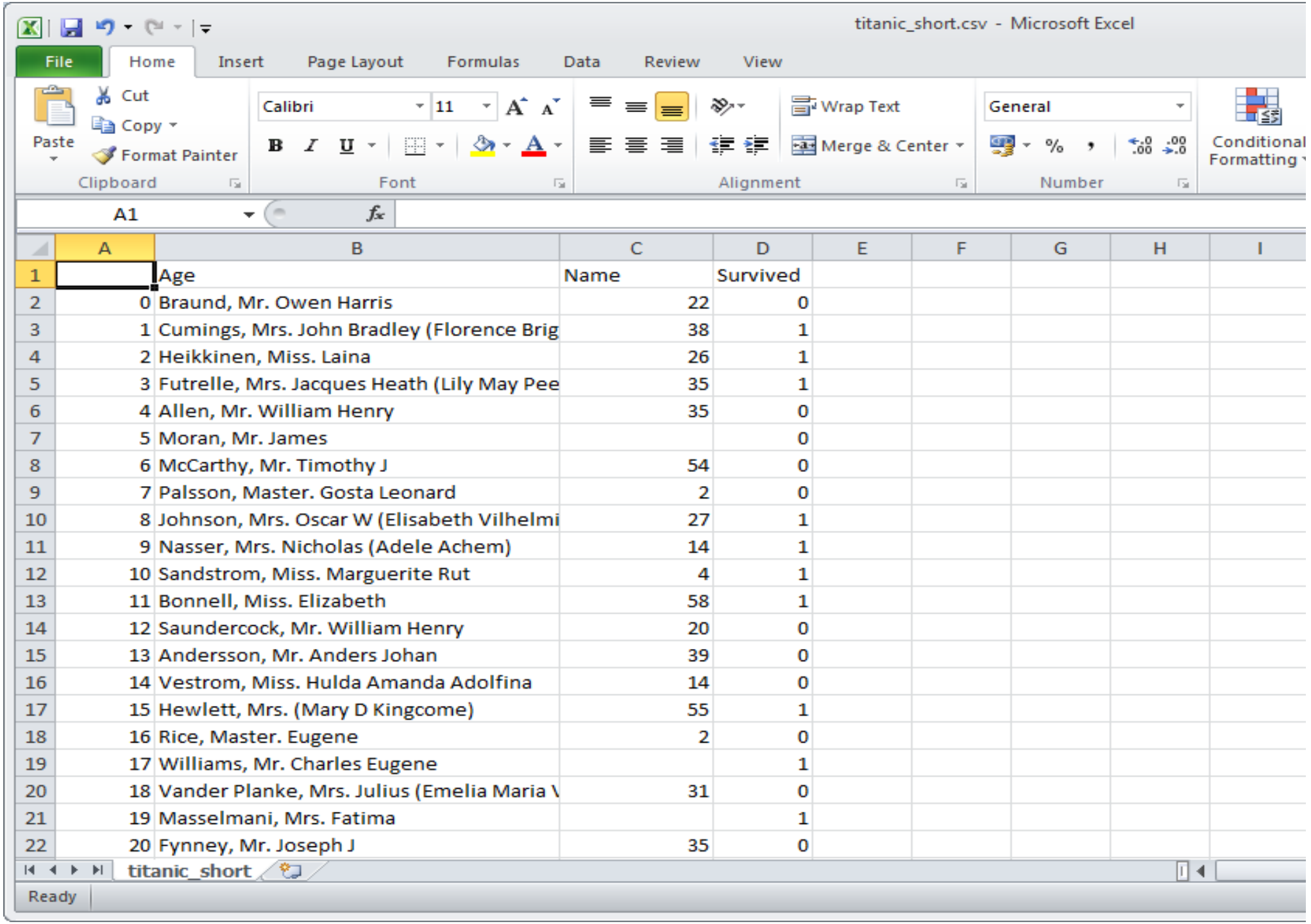
	Sex	Age	SibSp	Parch	Ticket	Fare	Cabin	\
803	male	0.42	0	1	2625	8.5167	NaN	
755	male	0.67	1	1	250649	14.5000	NaN	
469	female	0.75	2	1	2666	19.2583	NaN	
644	female	0.75	2	1	2666	19.2583	NaN	
78	male	0.83	0	2	248738	29.0000	NaN	
831	male	0.83	1	1	29106	18.7500	NaN	
305	male	0.92	1	2	113781	151.5500	C22 C26	
386	male	1.00	5	2	CA 2144	46.9000	NaN	
164	male	1.00	4	1	3101295	39.6875	NaN	
183	male	1.00	2	1	230136	39.0000	F4	
827	male	1.00	0	2	S.C./PARIS 2079	37.0042	NaN	
788	male	1.00	1	2	C.A. 2315	20.5750	NaN	
381	female	1.00	0	2	2653	15.7417	NaN	
172	female	1.00	1	1	347742	11.1333	NaN	
297	female	2.00	1	2	113781	151.5500	C22 C26	
824	male	2.00	4	1	3101295	39.6875	NaN	
119	female	2.00	4	2	347082	31.2750	NaN	
16	male	2.00	4	1	382652	29.1250	NaN	
642	female	2.00	3	2	347088	27.9000	NaN	
340	male	2.00	1	1	230080	26.0000	F2	
530	female	2.00	1	1	26360	26.0000	NaN	
7	male	2.00	3	1	349909	21.0750	NaN	
479	female	2.00	0	1	3101298	12.2875	NaN	
205	female	2.00	0	1	347054	10.4625	G6	
43	female	3.00	1	2	SC/Paris 2123	41.5792	NaN	

Notice the data is arranged in ascending age but in descending fare

Storing the Data in a File

- I want to extract three columns (name, age, survived) from the dataset and store them as a new dataset file. To write a dataframe to a file you can just use the to_csv function that takes in the name of the file you want to write the data to.
- In the example below we extract a subset of the titanic dataset (age, name and survived columns and write that data to the csv file)

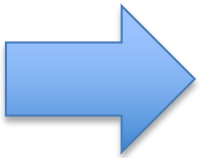
```
df = read_csv("titanic.csv")

shortDataframe = df[['Age', 'Name', 'Survived']]

shortDataframe.to_csv('titanic_short.csv')
```



	A	B	C	D	E	F	G	H	I
1		Age	Name	Survived					
2	0	Braund, Mr. Owen Harris	22	0					
3	1	Cumings, Mrs. John Bradley (Florence Brig	38	1					
4	2	Heikkinen, Miss. Laina	26	1					
5	3	Futrelle, Mrs. Jacques Heath (Lily May Pee	35	1					
6	4	Allen, Mr. William Henry	35	0					
7	5	Moran, Mr. James		0					
8	6	McCarthy, Mr. Timothy J	54	0					
9	7	Palsson, Master. Gosta Leonard	2	0					
10	8	Johnson, Mrs. Oscar W (Elisabeth Vilhelmi	27	1					
11	9	Nasser, Mrs. Nicholas (Adele Achem)	14	1					
12	10	Sandstrom, Miss. Marguerite Rut	4	1					
13	11	Bonnell, Miss. Elizabeth	58	1					
14	12	Saundercock, Mr. William Henry	20	0					
15	13	Andersson, Mr. Anders Johan	39	0					
16	14	Vestrom, Miss. Hulda Amanda Adolfina	14	0					
17	15	Hewlett, Mrs. (Mary D Kingcome)	55	1					
18	16	Rice, Master. Eugene	2	0					
19	17	Williams, Mr. Charles Eugene		1					
20	18	Vander Planke, Mrs. Julius (Emelia Maria V	31	0					
21	19	Masselmani, Mrs. Fatima		1					
22	20	Fynney, Mr. Joseph J	35	0					

Contents

- Introduction to Pandas Series and Dataframe data structures.
- Reading data into a Dataframe
- Accessing Data from a Dataframe
- Merging and Grouping Data



Merging Data

- **pandas.merge** allows two DataFrames to be joined on one or more keys. The function provides a series of parameters allowing you to specify the columns or indexes on which to join

how : {'left', 'right', 'outer', 'inner'}, default 'inner'

left: use only keys from left frame (SQL: left outer join)

right: use only keys from right frame (SQL: right outer join)

outer: use union of keys from both frames (SQL: full outer join)

inner: use intersection of keys from both frames (SQL: inner join)

Merging Data

- This kind of merging is very useful if you have separate datasets with a common key
- Default join is an inner join (selects all rows from both tables as long as there is a match between the columns in both tables)

```
left = pd.DataFrame({'names': ['john', 'tim', 'tom'], 'colLeft': [1, 2, 3]})
right = pd.DataFrame({'names': ['fred', 'tim', 'tom'], 'colRight': [4, 5, 6]})

print left
print right
print
print pd.merge(left, right, on='names', how='inner')
```

```
   colLeft names
0        1  john
1        2   tim
2        3   tom

   colRight names
0         4  fred
1         5   tim
2         6   tom

   colLeft names  colRight
0        2   tim         5
1        3   tom         6
```

Notice that we lose values from both frames since certain keys do not match up

Merging Data – Outer Join

- The following is an example of an **outer join**.
- We keep everything from both frames, regardless of whether or not there was a match on both sides. Where there was not a match, the values corresponding to that key are NULL (NaN).

```
left = pd.DataFrame({'names': ['john', 'tim', 'tom'], 'colLeft': [1, 2, 3]})
right = pd.DataFrame({'names': ['fred', 'tim', 'tom'], 'colRight': [4, 5, 6]})

print left
print
print right
print
print merge(left, right, on='names', how='outer')
```

```
   colLeft names
0        1  john
1        2   tim
2        3   tom

   colRight names
0         4  fred
1         5   tim
2         6   tom

   colLeft names  colRight
0        1  john       NaN
1        2   tim         5
2        3   tom         6
3      NaN  fred         4
```

Merging Data

- The following is an example of a left outer join.
  - We keep everything from the left frame, pulling in the value from the right frame where the keys match up. The right_value is NULL where keys do not match (NaN).

```
left = pd.DataFrame({'names': ['john', 'tim', 'tom'], 'colLeft': [1, 2, 3]})
right = pd.DataFrame({'names': ['fred', 'tim', 'tom'], 'colRight': [4, 5, 6]})

print left
print
print right
print
print merge(left, right, on='names', how='left')
```

```
   colLeft names
0        1  john
1        2   tim
2        3   tom

   colRight names
0         4  fred
1         5   tim
2         6   tom

   colLeft names  colRight
0        1  john       NaN
1        2   tim         5
2        3   tom         6
```

Merging Data

- The following is an example of a right outer join.
  - This time we've kept everything from the right frame with the left_value being NULL where the right frame's key did not find a match.

```
print merge(left, right, on='names', how='right')
```

```
   colLeft names
0        1  john
1        2   tim
2        3   tom

   colRight names
0         4  fred
1         5   tim
2         6   tom

   colLeft names  colRight
0        2   tim         5
1        3   tom         6
2      NaN  fred         4
```

Merging Data On Index

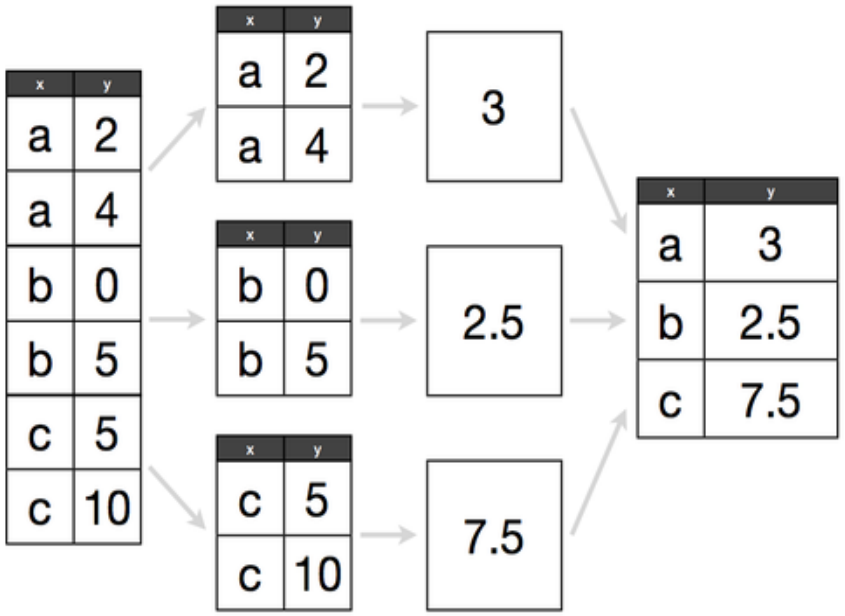
```
import pandas as pd

left = pd.DataFrame({'names': ['john', 'tim', 'tom'], 'colLeft': [1, 2, 3]})
right = pd.DataFrame({'names': ['fred', 'tim', 'tom'], 'colRight': [4, 5, 6]})

print left
print right
print
print pd.merge(left, right, right_index=True, left_index=True)
```

```
   colLeft names
0        1  john
1        2   tim
2        3   tom
   colRight names
0         4  fred
1         5   tim
2         6   tom

   colLeft names_x  colRight names_y
0        1    john         4    fred
1        2     tim         5     tim
2        3     tom         6     tom
```

Using GroupBy

- When approaching a data analysis problem, you'll often break it apart into manageable pieces, perform some operations on each of the pieces, and then put everything back together again.

- Pandas groupby method is useful for this as it facilitates the following steps:
  - Splitting the data into groups based on some criteria
  - Applying a function to each group independently
  - Combining the results into a data structure



Using GroupBy

- Pandas groupby function returns a DataFrameGroupBy object which has a variety of methods
  - Count returns the total number of NOT NULL values within each column.
  - For example 186 of the entries in the Age column have a Pclass of 1

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

sorted = df.groupby('Pclass')
print sorted.count()
```

```
<pandas.core.groupby.DataFrameGroupBy object at 0x0629F0B0>
        PassengerId  Survived  Name  Sex  Age  SibSp  Parch  Ticket  Fare  \
Pclass
1               216       216   216  216  186    216    216     216   216
2               184       184   184  184  173    184    184     184   184
3               491       491   491  491  355    491    491     491   491

        Cabin  Embarked
Pclass
1         176       214
2          16       184
3          12       491
```

Using GroupBy

- You can perform mathematical operations such as sum, median, mean on the groupby object.
- For example, lets try to find out the average price paid by first class, second class and third class passengers

```
groupDF = df.groupby('Pclass')
print groupDF['Fare']
print groupDF['Fare'].mean()

print
print groupDF['Age'].mean()
```

```
<pandas.core.groupby.SeriesGroupBy object at 0x062460D0>
Pclass
1          84.154687
2          20.662183
3          13.675550
Name: Fare, dtype: float64

Pclass
1          38.233441
2          29.877630
3          25.140620
Name: Age, dtype: float64
```

GroupBy

- The size method is a simple but useful methods that returns the number of entries in each group.
- For example lets determine the top 10 most common ages on the titanic voyage.

```
groupDF = df.groupby('Age')

print groupDF.size().order(ascending=False).head(10)
```

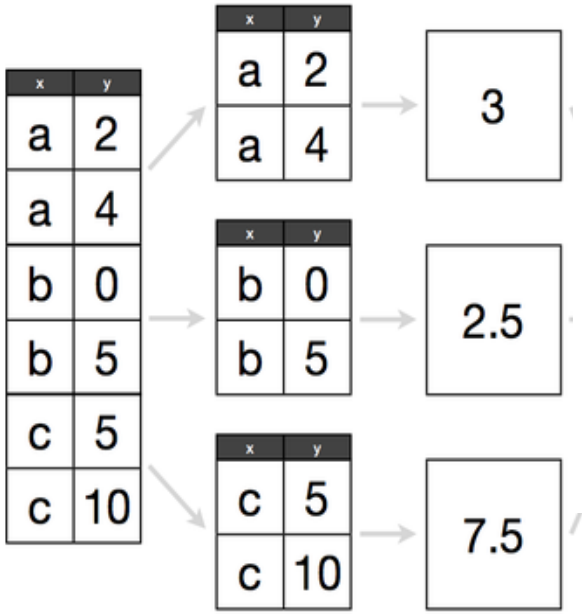
```
Age
24      30
22      27
18      26
30      25
19      25
28      25
21      24
25      23
36      22
29      20
dtype: int64
```

The .size method will return the number of entries for each unique age in the dataset. For example, 30 of the entries have an age of 24.

Using GroupBy

- When approaching a data analysis problem, you'll often break it apart into manageable pieces and perform some operations on each of the pieces
  - http://pandas.pydata.org/pandas-docs/stable/groupby.html

- Pandas groupby method is useful for this as it facilitates the following steps:
  - Splitting the data into groups based on some criteria
  - Applying a function to each group independently



Using GroupBy

```
d = {'one':[1,1,1,1,1],
     'two':[2,2,2,2,2],
     'letter':['a','a','b','b','c']}

# Create dataframe
df = pd.DataFrame(d)
df
```

	letter	one	two
0	a	1	2
1	a	1	2
2	b	1	2
3	b	1	2
4	c	1	2

```
# Create group object
one = df.groupby('letter')

# Apply sum function
one.sum()
```

letter	one	two
a	2	4
b	2	4
c	1	2

Using GroupBy

- Pandas groupby function returns a DataFrameGroupBy object which has a variety of methods that we can apply
  - Count returns the total number of NOT NULL values within each column.
  - For example 186 of the entries in the Age column have a Pclass of 1
  - The count function returns a DataFrame object

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

sorted = df.groupby('Pclass')
print sorted.count()
```

```
<pandas.core.groupby.DataFrameGroupBy object at 0x0629F0B0>
        PassengerId  Survived  Name  Sex  Age  SibSp  Parch  Ticket  Fare  \
Pclass
1               216       216   216  216  186    216    216     216   216
2               184       184   184  184  173    184    184     184   184
3               491       491   491  491  355    491    491     491   491

        Cabin  Embarked
Pclass
1         176       214
2          16       184
3          12       491
```

Using Group By

We can group by multiple attributes

	letter	one	two
0	a	1	2
1	a	1	2
2	b	1	2
3	b	1	2
4	c	1	2

```
letterone = df.groupby(['letter','one']).sum()
Print letterone.sum()
```

		two
letter	one	
a	1	4
b	1	4
c	1	2

Using GroupBy

- In the example below we use the GroupBy object to group according to the attributes Pclass and Sex

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

sorted = df.groupby(['Pclass', 'Sex'])

print sorted.count()
```

Pclass	Sex	PassengerId	Survived	Name	Age	SibSp	Parch	Ticket	Fare	\
1	female	94	94	94	85	94	94	94	94	
	male	122	122	122	101	122	122	122	122	
2	female	76	76	76	74	76	76	76	76	
	male	108	108	108	99	108	108	108	108	
3	female	144	144	144	102	144	144	144	144	
	male	347	347	347	253	347	347	347	347	

Pclass	Sex	Cabin	Embarked
1	female	81	92
	male	95	122
2	female	10	76
	male	6	108
3	female	6	144
	male	6	347

Using GroupBy

- As we saw in previous slides you can perform mathematical operations such as sum, median, mean on the groupby object.
- For example, lets try to find out the average price paid by first class, second class and third class passengers
- It is important to note that these operators return either a Series or Dataframe object

```
groupDF = df.groupby('Pclass')
print groupDF['Fare'].mean()

print
print groupDF['Age'].mean()
```

```
<pandas.core.groupby.SeriesGroupBy object at 0x062460D0>
Pclass
1          84.154687
2          20.662183
3          13.675550
Name: Fare, dtype: float64

Pclass
1          38.233441
2          29.877630
3          25.140620
Name: Age, dtype: float64
```

GroupBy

- The size method is a simple but useful methods that returns the number of entries in each group.
- For example lets determine the top 10 most common ages on the titanic voyage. Again note the order function will return either a Series or DataFrame object

```
groupDF = df.groupby('Age')

print groupDF.size().order(ascending=False).head(10)
```

The .size method will return the number of entries for each unique age in the dataset. For example, 30 of the entries have an age of 24.

```
Age
24      30
22      27
18      26
30      25
19      25
28      25
21      24
25      23
36      22
29      20
dtype: int64
```

Using Pandas for Plotting

URL

- http://pandas.pydata.org/pandas-docs/stable/groupby.html
- http://synesthesiam.com/posts/an-introduction-to-pandas.html#getting-started
- http://www.gregreda.com/2013/10/26/working-with-pandas-dataframes/

- Need to include material on mathplotlib with pandas as well.

Combing Condition using &

- Of course we can take a shortcut and **embed the conditions** as follows. Below I want to retrieve those individual that are aged over 40 or are male

```
print df[(df['Age'] > 40) | (df['Sex'] == 'male')].head(10)
```

	PassengerId	Survived	Pclass	Name	Sex
0	1	0	3	Braund, Mr. Owen Harris	male
4	5	0	3	Allen, Mr. William Henry	male
5	6	0	3	Moran, Mr. James	male
6	7	0	1	McCarthy, Mr. Timothy J	male
7	8	0	3	Palsson, Master. Gosta Leonard	male
11	12	1	1	Bonnell, Miss. Elizabeth	female
12	13	0	3	Saundercock, Mr. William Henry	male
13	14	0	3	Andersson, Mr. Anders Johan	male
15	16	1	2	Hewlett, Mrs. (Mary D Kingcome)	female
16	17	0	3	Rice, Master. Eugene	male

	Age	SibSp	Parch	Ticket	Fare	Cabin	Embarked
0	22	1	0	A/5 21171	7.2500	NaN	S
4	35	0	0	373450	8.0500	NaN	S
5	NaN	0	0	330877	8.4583	NaN	Q
6	54	0	0	17463	51.8625	E46	S
7	2	3	1	349909	21.0750	NaN	S
11	58	0	0	113783	26.5500	C103	S
12	20	0	0	A/5. 2151	8.0500	NaN	S
13	39	1	5	347082	31.2750	NaN	S
15	55	0	0	248706	16.0000	NaN	S
16	2	4	1	382652	29.1250	NaN	Q

Data Frame Analysis - Sorting

- If I wanted to sort the data in terms of ascending age and descending fare.

```
sorted = df.sort(['Age', 'Fare'], ascending=[True, False])
```

	Sex	Age	SibSp	Parch	Ticket	Fare	Cabin	\
803	male	0.42	0	1	2625	8.5167	NaN	
755	male	0.67	1	1	250649	14.5000	NaN	
469	female	0.75	2	1	2666	19.2583	NaN	
644	female	0.75	2	1	2666	19.2583	NaN	
78	male	0.83	0	2	248738	29.0000	NaN	
831	male	0.83	1	1	29106	18.7500	NaN	
305	male	0.92	1	2	113781	151.5500	C22 C26	
386	male	1.00	5	2	CA 2144	46.9000	NaN	
164	male	1.00	4	1	3101295	39.6875	NaN	
183	male	1.00	2	1	230136	39.0000	F4	
827	male	1.00	0	2	S.C./PARIS 2079	37.0042	NaN	
788	male	1.00	1	2	C.A. 2315	20.5750	NaN	
381	female	1.00	0	2	2653	15.7417	NaN	
172	female	1.00	1	1	347742	11.1333	NaN	
297	female	2.00	1	2	113781	151.5500	C22 C26	
824	male	2.00	4	1	3101295	39.6875	NaN	
119	female	2.00	4	2	347082	31.2750	NaN	
16	male	2.00	4	1	382652	29.1250	NaN	
642	female	2.00	3	2	347088	27.9000	NaN	
340	male	2.00	1	1	230080	26.0000	F2	
530	female	2.00	1	1	26360	26.0000	NaN	
7	male	2.00	3	1	349909	21.0750	NaN	
479	female	2.00	0	1	3101298	12.2875	NaN	
205	female	2.00	0	1	347054	10.4625	G6	
43	female	3.00	1	2	SC/Paris 2123	41.5792	NaN	

Notice the data is arranged in ascending age but in descending fare

Titanic - Dataset

SPECIAL NOTES:

Pclass is a proxy for socio-economic status (SES)
1st ~ Upper; 2nd ~ Middle; 3rd ~ Lower

Age is in Years; Fractional if Age less than One (1)
If the Age is Estimated, it is in the form xx.5

With respect to the family relation variables (i.e. sibsp and parch)
some relations were ignored. The following are the definitions used
for sibsp and parch.

Sibling: Brother, Sister, Stepbrother, or Stepsister of Passenger Aboard Titanic
Spouse: Husband or Wife of Passenger Aboard Titanic (Mistresses and Fiancees Ignored)
Parent: Mother or Father of Passenger Aboard Titanic
Child: Son, Daughter, Stepson, or Stepdaughter of Passenger Aboard Titanic