Pandas 1

Content

Introduction to Pandas

Pandas Installation

In [3]:
```
# !pip install pandas    -- remove hashtag and run this command if pandas is
```

Importing Pandas

- You should be able to import Pandas after installing it.
- We'll import `pandas` using its **alias name** **`pd`**.

In [4]:
```
import pandas as pd
import numpy as np
```

Why use Pandas?

- The major **limitation of numpy** is that it can only work with one datatype at a time.
- Most real-world datasets contain a mix of different datatypes.
  - **names of a place would be string**
  - **population of a place would be int**

It is difficult to work with data having **heterogeneous values** using Numpy.

On the other hand, Pandas can work with numbers and strings together.

Problem Statement

- Imagine that you are a Data Scientist with McKinsey.
- McKinsey wants to understand the relation between GDP per capita and life expectancy for their clients.
- The company has obtained data from various surveys conducted in different countries over several years.
- The acquired data includes information on
  - Country
  - Population Size
  - Life Expectancy
  - GDP per Capita
- We have to analyse the data and draw inferences that are meaningful to the company.

Now how should we read this dataset?

Pandas makes it very easy to work with these kinds of files.

In [5]:
```
df = pd.read_csv('mckinsey.csv') # storing the data in df
df
```

Out[5]:

	country	year	population	continent	life_exp	gdp_cap
0	Afghanistan	1952	8425333	Asia	28.801	779.445314
1	Afghanistan	1957	9240934	Asia	30.332	820.853030
2	Afghanistan	1962	10267083	Asia	31.997	853.100710
3	Afghanistan	1967	11537966	Asia	34.020	836.197138
4	Afghanistan	1972	13079460	Asia	36.088	739.981106
...	...	...	...	...	...	...
1699	Zimbabwe	1987	9216418	Africa	62.351	706.157306
1700	Zimbabwe	1992	10704340	Africa	60.377	693.420786
1701	Zimbabwe	1997	11404948	Africa	46.809	792.449960
1702	Zimbabwe	2002	11926563	Africa	39.989	672.038623
1703	Zimbabwe	2007	12311143	Africa	43.487	469.709298

1704 rows × 6 columns

DataFrame and Series

What can we observe from the above dataset?

We can see that it has:

- 6 columns
- 1704 rows

What do you think is the datatype of `df` ?

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

Out[6]:
```
pandas.core.frame.DataFrame
```

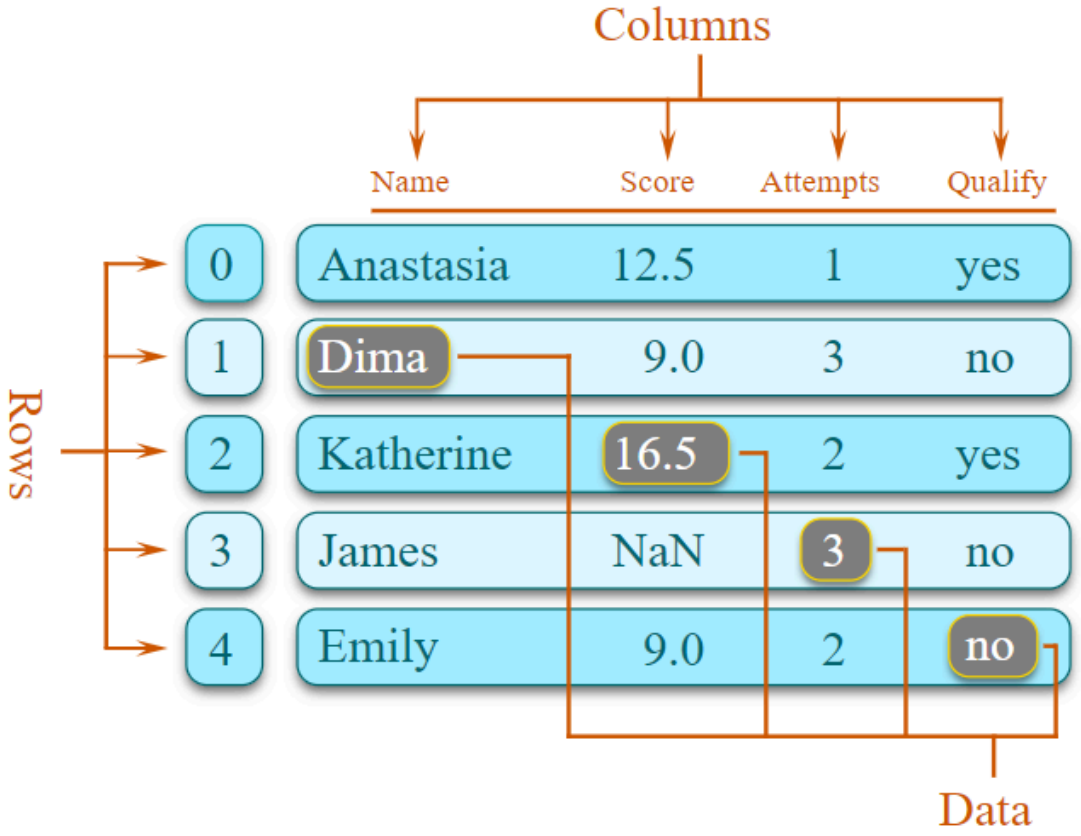
It is a **Pandas DataFrame**

What is a Pandas DataFrame?

- A DataFrame is a **table-like (structured)** representation of data in Pandas.
- Considered as a **counterpart of 2D matrix** in Numpy.

In [7]:
```
from IPython.display import Image
Image(filename='download.png')
```

Out[7]:



How can we access a column, say `country` of the dataframe?

In [8]:
```
df["country"]
```

Out[8]:
```
0       Afghanistan
1       Afghanistan
2       Afghanistan
3       Afghanistan
4       Afghanistan
           ...
1699       Zimbabwe
1700       Zimbabwe
1701       Zimbabwe
1702       Zimbabwe
1703       Zimbabwe
Name: country, Length: 1704, dtype: object
```

As you can see, we get all the values present in the **country** column.

What is the data-type of a column?

In [9]:
```
type(df["country"])
```

Out[9]:
```
pandas.core.series.Series
```

It is a **Pandas Series**

What is a Pandas Series?

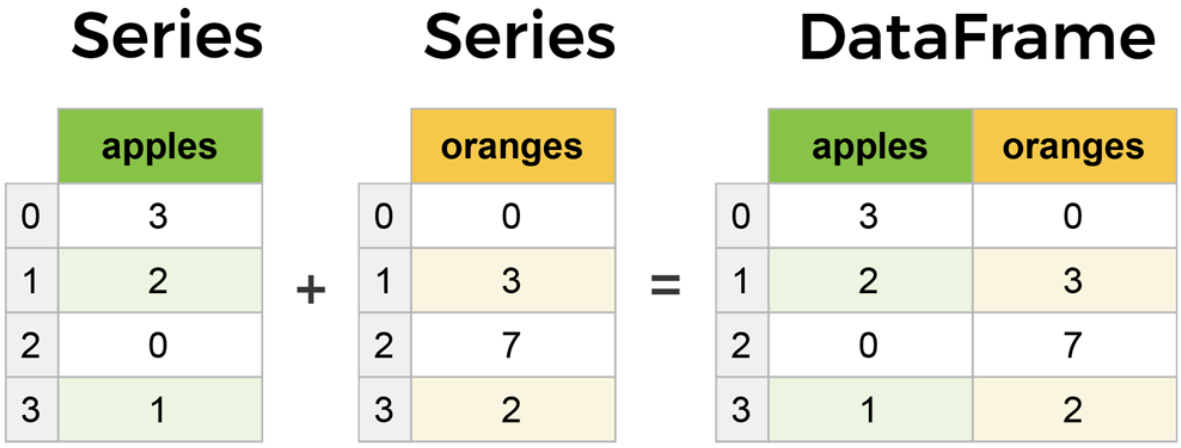
- A **Series** in Pandas is what a **Vector** is in Numpy.

What exactly does that mean?

- It means that a Series is a **single column of data**.
- Multiple Series are stacked together to form a DataFrame.

In [10]:
```
from IPython.display import Image
Image(filename='series.png')
```

Out[10]:



Now we have understood what Series and DataFrame are.

How can we find the datatype, name, total entries in each column?

In [11]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1704 entries, 0 to 1703
Data columns (total 6 columns):
 #   Column      Non-Null Count  Dtype  
---  ------      --------------  -----  
 0   country     1704 non-null   object 
 1   year        1704 non-null   int64  
 2   population  1704 non-null   int64  
 3   continent   1704 non-null   object 
 4   life_exp    1704 non-null   float64
 5   gdp_cap     1704 non-null   float64
dtypes: float64(2), int64(2), object(2)
memory usage: 80.0+ KB
```

`df.info()` gives a list of columns with:

- **Name** of columns

- **How many non-null values (blank cells)** each column has.
- **Type of values** in each column - int, float, etc.

By default, it shows **Dtype** as `object` for anything other than **int or float**.

What if we want to see the first few rows in the dataset?

In [12]:
```
df.head()
```

Out[12]:

	country	year	population	continent	life_exp	gdp_cap
0	Afghanistan	1952	8425333	Asia	28.801	779.445314
1	Afghanistan	1957	9240934	Asia	30.332	820.853030
2	Afghanistan	1962	10267083	Asia	31.997	853.100710
3	Afghanistan	1967	11537966	Asia	34.020	836.197138
4	Afghanistan	1972	13079460	Asia	36.088	739.981106

`df.head()` prints the top 5 rows by default.

We can also pass in number of rows that we want to see.

In [13]:
```
df.head(10)
```

Out[13]:

	country	year	population	continent	life_exp	gdp_cap
0	Afghanistan	1952	8425333	Asia	28.801	779.445314
1	Afghanistan	1957	9240934	Asia	30.332	820.853030
2	Afghanistan	1962	10267083	Asia	31.997	853.100710
3	Afghanistan	1967	11537966	Asia	34.020	836.197138
4	Afghanistan	1972	13079460	Asia	36.088	739.981106
5	Afghanistan	1977	14880372	Asia	38.438	786.113360
6	Afghanistan	1982	12881816	Asia	39.854	978.011439
7	Afghanistan	1987	13867957	Asia	40.822	852.395945
8	Afghanistan	1992	16317921	Asia	41.674	649.341395
9	Afghanistan	1997	22227415	Asia	41.763	635.341351

Similarly, we can use **`df.tail()` if we wish to see the last few rows**.

In [14]:
```
df.tail()
```

Out[14]:

	country	year	population	continent	life_exp	gdp_cap
1699	Zimbabwe	1987	9216418	Africa	62.351	706.157306
1700	Zimbabwe	1992	10704340	Africa	60.377	693.420786
1701	Zimbabwe	1997	11404948	Africa	46.809	792.449960
1702	Zimbabwe	2002	11926563	Africa	39.989	672.038623
1703	Zimbabwe	2007	12311143	Africa	43.487	469.709298

How can we find the shape of a dataframe?

In [15]:
```
df.shape
```

Out[15]:
```
(1704, 6)
```

Similar to Numpy, it gives the **no. of rows and columns**.

Basic operations on Columns

What operations can we do using columns?

- Add a column
- Delete a column
- Rename a column

We can see that our dataset has 6 columns.

How can we get the names of all these cols?

We can do it in two ways:

1. `df.columns`
2. `df.keys`

In [16]:
```
df.columns  # using attribute `columns` of dataframe
```

Out[16]:
```
Index(['country', 'year', 'population', 'continent', 'life_exp', 'gdp_ca
p'], dtype='object')
```

In [17]:
```
df.keys()  # using method `keys()` of dataframe
```

Out[17]:
```
Index(['country', 'year', 'population', 'continent', 'life_exp', 'gdp_ca
p'], dtype='object')
```

Note:

- Here, `Index` is a type of Pandas class used to store the `address` of the series/dataframe.
- It is an immutable sequence used for indexing.

How can we access these columns?

In [18]:
```
df['country'].head()  # accessing a single column
```

Out[18]:
```
0    Afghanistan
1    Afghanistan
2    Afghanistan
3    Afghanistan
4    Afghanistan
Name: country, dtype: object
```

In [19]:
```
df[['country', 'life_exp']].head() # accessing multiple columns
```

Out[19]:

	country	life_exp
0	Afghanistan	28.801
1	Afghanistan	30.332
2	Afghanistan	31.997
3	Afghanistan	34.020
4	Afghanistan	36.088

And what if we pass a single column name?

In [20]:
```
df[['country']].head()
```

Out[20]:

	country
0	Afghanistan
1	Afghanistan
2	Afghanistan
3	Afghanistan
4	Afghanistan

Note:

- Notice how this output type is different from our earlier output using `df['country']`
- `['country']` gives a Series while `[['country']]` gives a DataFrame.

How can we find the countries that have been surveyed?

We can find the unique values in the `country` column.

In [21]:
```
df['country'].unique()
```

Out[21]:
```
array(['Afghanistan', 'Albania', 'Algeria', 'Angola', 'Argentina',
       'Australia', 'Austria', 'Bahrain', 'Bangladesh', 'Belgium',
       'Benin', 'Bolivia', 'Bosnia and Herzegovina', 'Botswana', 'Brazil',
       'Bulgaria', 'Burkina Faso', 'Burundi', 'Cambodia', 'Cameroon',
       'Canada', 'Central African Republic', 'Chad', 'Chile', 'China',
       'Colombia', 'Comoros', 'Congo, Dem. Rep.', 'Congo, Rep.',
       'Costa Rica', "Cote d'Ivoire", 'Croatia', 'Cuba', 'Czech Republic',
       'Denmark', 'Djibouti', 'Dominican Republic', 'Ecuador', 'Egypt',
       'El Salvador', 'Equatorial Guinea', 'Eritrea', 'Ethiopia',
       'Finland', 'France', 'Gabon', 'Gambia', 'Germany', 'Ghana',
       'Greece', 'Guatemala', 'Guinea', 'Guinea-Bissau', 'Haiti',
       'Honduras', 'Hong Kong, China', 'Hungary', 'Iceland', 'India',
       'Indonesia', 'Iran', 'Iraq', 'Ireland', 'Israel', 'Italy',
       'Jamaica', 'Japan', 'Jordan', 'Kenya', 'Korea, Dem. Rep.',
       'Korea, Rep.', 'Kuwait', 'Lebanon', 'Lesotho', 'Liberia', 'Libya',
       'Madagascar', 'Malawi', 'Malaysia', 'Mali', 'Mauritania',
       'Mauritius', 'Mexico', 'Mongolia', 'Montenegro', 'Morocco',
       'Mozambique', 'Myanmar', 'Namibia', 'Nepal', 'Netherlands',
       'New Zealand', 'Nicaragua', 'Niger', 'Nigeria', 'Norway', 'Oman',
       'Pakistan', 'Panama', 'Paraguay', 'Peru', 'Philippines', 'Poland',
       'Portugal', 'Puerto Rico', 'Reunion', 'Romania', 'Rwanda',
       'Sao Tome and Principe', 'Saudi Arabia', 'Senegal', 'Serbia',
       'Sierra Leone', 'Singapore', 'Slovak Republic', 'Slovenia',
       'Somalia', 'South Africa', 'Spain', 'Sri Lanka', 'Sudan',
       'Swaziland', 'Sweden', 'Switzerland', 'Syria', 'Taiwan',
       'Tanzania', 'Thailand', 'Togo', 'Trinidad and Tobago', 'Tunisia',
       'Turkey', 'Uganda', 'United Kingdom', 'United States', 'Uruguay',
       'Venezuela', 'Vietnam', 'West Bank and Gaza', 'Yemen, Rep.',
       'Zambia', 'Zimbabwe'], dtype=object)
```

What if you also want to check the count of occurence of each country in the dataframe?

In [22]:
```
df['country'].value_counts()
```

Out[22]:
```
Afghanistan          12
Pakistan             12
New Zealand          12
Nicaragua            12
Niger                12
                     ..
Eritrea              12
Equatorial Guinea    12
El Salvador          12
Egypt                12
Zimbabwe             12
Name: country, Length: 142, dtype: int64
```

Note: `value_counts()` shows the output in **decreasing order of frequency**.

What if we want to change the name of a column?

We can rename the column by

- passing the dictionary with `old_name:new_name` pair
- specifying `axis=1`

In [23]:
```
df.rename({"population": "Population", "country":"Country" }, axis = 1)
```

Out[23]:

	Country	year	Population	continent	life_exp	gdp_cap
0	Afghanistan	1952	8425333	Asia	28.801	779.445314
1	Afghanistan	1957	9240934	Asia	30.332	820.853030
2	Afghanistan	1962	10267083	Asia	31.997	853.100710
3	Afghanistan	1967	11537966	Asia	34.020	836.197138
4	Afghanistan	1972	13079460	Asia	36.088	739.981106
...	...	...	...	...	...	...
1699	Zimbabwe	1987	9216418	Africa	62.351	706.157306
1700	Zimbabwe	1992	10704340	Africa	60.377	693.420786
1701	Zimbabwe	1997	11404948	Africa	46.809	792.449960
1702	Zimbabwe	2002	11926563	Africa	39.989	672.038623
1703	Zimbabwe	2007	12311143	Africa	43.487	469.709298

1704 rows × 6 columns

Alternatively, we can also rename the column

- without specifying `axis`
- by using the `column` parameter

In [24]:
```
df.rename(columns={"country":"Country"})
```

Out[24]:

	Country	year	population	continent	life_exp	gdp_cap
0	Afghanistan	1952	8425333	Asia	28.801	779.445314
1	Afghanistan	1957	9240934	Asia	30.332	820.853030
2	Afghanistan	1962	10267083	Asia	31.997	853.100710
3	Afghanistan	1967	11537966	Asia	34.020	836.197138
4	Afghanistan	1972	13079460	Asia	36.088	739.981106
...	...	...	...	...	...	...
1699	Zimbabwe	1987	9216418	Africa	62.351	706.157306
1700	Zimbabwe	1992	10704340	Africa	60.377	693.420786
1701	Zimbabwe	1997	11404948	Africa	46.809	792.449960
1702	Zimbabwe	2002	11926563	Africa	39.989	672.038623
1703	Zimbabwe	2007	12311143	Africa	43.487	469.709298

1704 rows × 6 columns

If we try and check the original dataframe `df` -

In [25]:
```
df
```

Out[25]:

	country	year	population	continent	life_exp	gdp_cap
0	Afghanistan	1952	8425333	Asia	28.801	779.445314
1	Afghanistan	1957	9240934	Asia	30.332	820.853030
2	Afghanistan	1962	10267083	Asia	31.997	853.100710
3	Afghanistan	1967	11537966	Asia	34.020	836.197138
4	Afghanistan	1972	13079460	Asia	36.088	739.981106
...	...	...	...	...	...	...
1699	Zimbabwe	1987	9216418	Africa	62.351	706.157306
1700	Zimbabwe	1992	10704340	Africa	60.377	693.420786
1701	Zimbabwe	1997	11404948	Africa	46.809	792.449960
1702	Zimbabwe	2002	11926563	Africa	39.989	672.038623
1703	Zimbabwe	2007	12311143	Africa	43.487	469.709298

1704 rows × 6 columns

We can clearly see that the column names are still the same and have not changed.

The changes doesn't happen in original dataframe unless we specify a parameter called `inplace` as True.

In [26]:
```
df.rename({"country": "Country"}, axis = 1, inplace = True)
df
```

Out[26]:

	Country	year	population	continent	life_exp	gdp_cap
0	Afghanistan	1952	8425333	Asia	28.801	779.445314
1	Afghanistan	1957	9240934	Asia	30.332	820.853030
2	Afghanistan	1962	10267083	Asia	31.997	853.100710
3	Afghanistan	1967	11537966	Asia	34.020	836.197138
4	Afghanistan	1972	13079460	Asia	36.088	739.981106
...	...	...	...	...	...	...
1699	Zimbabwe	1987	9216418	Africa	62.351	706.157306
1700	Zimbabwe	1992	10704340	Africa	60.377	693.420786
1701	Zimbabwe	1997	11404948	Africa	46.809	792.449960
1702	Zimbabwe	2002	11926563	Africa	39.989	672.038623
1703	Zimbabwe	2007	12311143	Africa	43.487	469.709298

1704 rows × 6 columns

Note

- `.rename` has default value of axis=0
- If two columns have the **same name**, then `df['column']` will display both columns.

There's another way of accessing the column values.

In [27]:
```
df.Country
```

Out[27]:
```
0       Afghanistan
1       Afghanistan
2       Afghanistan
3       Afghanistan
4       Afghanistan
           ...
1699       Zimbabwe
1700       Zimbabwe
1701       Zimbabwe
1702       Zimbabwe
1703       Zimbabwe
Name: Country, Length: 1704, dtype: object
```

This however doesn't work everytime.

What do you think could be the problem here?

- If the column names are **not strings**
  - Starting with **number**: e.g. `2nd`
  - Contains a **whitespace**: e.g. `Roll Number`
- If the column names conflict with **methods of the DataFrame**
  - e.g. `shape`

We already know the continents in which each country lies.

So we probably don't need this column.

How can we delete columns from a dataframe?

In [28]:
```
df.drop('continent', axis=1)
```

Out[28]:

	Country	year	population	life_exp	gdp_cap
0	Afghanistan	1952	8425333	28.801	779.445314
1	Afghanistan	1957	9240934	30.332	820.853030
2	Afghanistan	1962	10267083	31.997	853.100710
3	Afghanistan	1967	11537966	34.020	836.197138
4	Afghanistan	1972	13079460	36.088	739.981106
...	...	...	...	...	...
1699	Zimbabwe	1987	9216418	62.351	706.157306
1700	Zimbabwe	1992	10704340	60.377	693.420786
1701	Zimbabwe	1997	11404948	46.809	792.449960
1702	Zimbabwe	2002	11926563	39.989	672.038623
1703	Zimbabwe	2007	12311143	43.487	469.709298

1704 rows × 5 columns

The `drop()` function takes two parameters:

- column name
- axis

By default, the value of `axis` is 0.

An alternative to the above approach is using the "columns" parameter as we did in `rename()`.

In [29]:
```
df.drop(columns=['continent'])
```

Out[29]:

	Country	year	population	life_exp	gdp_cap
0	Afghanistan	1952	8425333	28.801	779.445314
1	Afghanistan	1957	9240934	30.332	820.853030
2	Afghanistan	1962	10267083	31.997	853.100710
3	Afghanistan	1967	11537966	34.020	836.197138
4	Afghanistan	1972	13079460	36.088	739.981106
...	...	...	...	...	...
1699	Zimbabwe	1987	9216418	62.351	706.157306
1700	Zimbabwe	1992	10704340	60.377	693.420786
1701	Zimbabwe	1997	11404948	46.809	792.449960
1702	Zimbabwe	2002	11926563	39.989	672.038623
1703	Zimbabwe	2007	12311143	43.487	469.709298

1704 rows × 5 columns

As you can see, the column `contintent` is dropped.

Has the column been permanently deleted?

In [30]:
```
df.head()
```

Out[30]:

	Country	year	population	continent	life_exp	gdp_cap
0	Afghanistan	1952	8425333	Asia	28.801	779.445314
1	Afghanistan	1957	9240934	Asia	30.332	820.853030
2	Afghanistan	1962	10267083	Asia	31.997	853.100710
3	Afghanistan	1967	11537966	Asia	34.020	836.197138
4	Afghanistan	1972	13079460	Asia	36.088	739.981106

No, the column `continent` is still there in the original dataframe.

Do you see what's happening here?

We only got a **view of dataframe** with column `continent` dropped.

How can we permanently drop the column?

- We can either **re-assign** it `df = df.drop('continent', axis=1)`

- Or we can **set the parameter `inplace=True`**
  - By default, `inplace=False`.

In [31]:
```
df.drop('continent', axis=1, inplace=True)
```

What if we want to create a new column?

- We can either use values from **existing columns**.
- Or we can create our own values.

How to create a column using values from an existing column?

In [32]:
```
df["year+7"] = df["year"] + 7
df.head()
```

Out[32]:

	Country	year	population	life_exp	gdp_cap	year+7
0	Afghanistan	1952	8425333	28.801	779.445314	1959
1	Afghanistan	1957	9240934	30.332	820.853030	1964
2	Afghanistan	1962	10267083	31.997	853.100710	1969
3	Afghanistan	1967	11537966	34.020	836.197138	1974
4	Afghanistan	1972	13079460	36.088	739.981106	1979

As we see, a new column `year+7` is created from the column `year`.

We can also use values from two columns to form a new column.

Which two columns can we use to create a new column `gdp`?

In [33]:
```
df['gdp'] = df['gdp_cap'] * df['population']
df.head()
```

Out[33]:

	Country	year	population	life_exp	gdp_cap	year+7	gdp
0	Afghanistan	1952	8425333	28.801	779.445314	1959	6.567086e+09
1	Afghanistan	1957	9240934	30.332	820.853030	1964	7.585449e+09
2	Afghanistan	1962	10267083	31.997	853.100710	1969	8.758856e+09
3	Afghanistan	1967	11537966	34.020	836.197138	1974	9.648014e+09
4	Afghanistan	1972	13079460	36.088	739.981106	1979	9.678553e+09

As you can see

- An additional column has been created.
- Values in this column are **product of respective values in `gdp_cap` and `population` columns**.

What other operations we can use?

- Addition
- Subtraction
- Division

How can we create a new column from our own values?

- We can either **create a list**.
- Or we can **create a Pandas Series** from a list/numpy array for our new column.

In [34]:
```
df["Own"] = [i for i in range(1704)]  # count of these values should be cor
df
```

Out[34]:

	Country	year	population	life_exp	gdp_cap	year+7	gdp	Own
0	Afghanistan	1952	8425333	28.801	779.445314	1959	6.567086e+09	0
1	Afghanistan	1957	9240934	30.332	820.853030	1964	7.585449e+09	1
2	Afghanistan	1962	10267083	31.997	853.100710	1969	8.758856e+09	2
3	Afghanistan	1967	11537966	34.020	836.197138	1974	9.648014e+09	3
4	Afghanistan	1972	13079460	36.088	739.981106	1979	9.678553e+09	4
...	...	...	...	...	...	...	...	...
1699	Zimbabwe	1987	9216418	62.351	706.157306	1994	6.508241e+09	1699
1700	Zimbabwe	1992	10704340	60.377	693.420786	1999	7.422612e+09	1700
1701	Zimbabwe	1997	11404948	46.809	792.449960	2004	9.037851e+09	1701
1702	Zimbabwe	2002	11926563	39.989	672.038623	2009	8.015111e+09	1702
1703	Zimbabwe	2007	12311143	43.487	469.709298	2014	5.782658e+09	1703

1704 rows × 8 columns

Before we move to ops on rows, let's drop the newly created columns.

In [35]:
```
df.drop(columns=["Own",'gdp', 'year+7'], axis = 1, inplace = True)
df
```

Out[35]:

	Country	year	population	life_exp	gdp_cap
0	Afghanistan	1952	8425333	28.801	779.445314
1	Afghanistan	1957	9240934	30.332	820.853030
2	Afghanistan	1962	10267083	31.997	853.100710
3	Afghanistan	1967	11537966	34.020	836.197138
4	Afghanistan	1972	13079460	36.088	739.981106
...	...	...	...	...	...
1699	Zimbabwe	1987	9216418	62.351	706.157306
1700	Zimbabwe	1992	10704340	60.377	693.420786
1701	Zimbabwe	1997	11404948	46.809	792.449960
1702	Zimbabwe	2002	11926563	39.989	672.038623
1703	Zimbabwe	2007	12311143	43.487	469.709298

1704 rows × 5 columns

Basic operations on Rows

Just like columns, do rows also have labels? Yes.

- **Can we change row labels (like we did for columns)?**
- **What if we want to start indexing from 1 (instead of 0)?**

In [36]:
```
df.index = list(range(1, df.shape[0]+1)) # create a list of indices of same
df
```

Out[36]:

	Country	year	population	life_exp	gdp_cap
1	Afghanistan	1952	8425333	28.801	779.445314
2	Afghanistan	1957	9240934	30.332	820.853030
3	Afghanistan	1962	10267083	31.997	853.100710
4	Afghanistan	1967	11537966	34.020	836.197138
5	Afghanistan	1972	13079460	36.088	739.981106
...	...	...	...	...	...
1700	Zimbabwe	1987	9216418	62.351	706.157306
1701	Zimbabwe	1992	10704340	60.377	693.420786
1702	Zimbabwe	1997	11404948	46.809	792.449960
1703	Zimbabwe	2002	11926563	39.989	672.038623
1704	Zimbabwe	2007	12311143	43.487	469.709298

1704 rows × 5 columns

As you can see the indexing now starts from 1 instead of 0.

Explicit & Implicit Indices

What are these row labels/indices exactly?

- They can be called identifiers of a particular row.
- Specifically known as **explicit indices**.

Additionally, can a series/dataframe also use Python style indexing? Yes.

- The Python style indices are known as **implicit indices**.

How can we access explicit index of a particular row?

- using `df.index[]`
- Takes **impicit index** of row to give its **explicit index**.

In [37]:
```
df.index[1] # implicit index 1 gave explicit index 2
```

Out[37]:
```
2
```

But why not use just implicit indexing?

Explicit indices can be changed to any value of any datatype.

- e.g. explicit index of 1st row can be changed to `first`
- Or something like a floating point value, say `1.0`

In [38]:
```
df.index = np.arange(1, df.shape[0]+1, dtype='float')
df
```

Out[38]:

	Country	year	population	life_exp	gdp_cap
1.0	Afghanistan	1952	8425333	28.801	779.445314
2.0	Afghanistan	1957	9240934	30.332	820.853030
3.0	Afghanistan	1962	10267083	31.997	853.100710
4.0	Afghanistan	1967	11537966	34.020	836.197138
5.0	Afghanistan	1972	13079460	36.088	739.981106
...	...	...	...	...	...
1700.0	Zimbabwe	1987	9216418	62.351	706.157306
1701.0	Zimbabwe	1992	10704340	60.377	693.420786
1702.0	Zimbabwe	1997	11404948	46.809	792.449960
1703.0	Zimbabwe	2002	11926563	39.989	672.038623
1704.0	Zimbabwe	2007	12311143	43.487	469.709298

1704 rows × 5 columns

As we can see, the indices are now floating point values.

Now to understand string indices, let's take a small subset of our original dataframe.

In [39]:
```
sample = df.head()
sample
```

Out[39]:

	Country	year	population	life_exp	gdp_cap
1.0	Afghanistan	1952	8425333	28.801	779.445314
2.0	Afghanistan	1957	9240934	30.332	820.853030
3.0	Afghanistan	1962	10267083	31.997	853.100710
4.0	Afghanistan	1967	11537966	34.020	836.197138
5.0	Afghanistan	1972	13079460	36.088	739.981106

What if we want to use string indices?

In [40]:
```
sample.index = ['a', 'b', 'c', 'd', 'e']
sample
```

Out[40]:

	Country	year	population	life_exp	gdp_cap
a	Afghanistan	1952	8425333	28.801	779.445314
b	Afghanistan	1957	9240934	30.332	820.853030
c	Afghanistan	1962	10267083	31.997	853.100710
d	Afghanistan	1967	11537966	34.020	836.197138
e	Afghanistan	1972	13079460	36.088	739.981106

This shows us that we can use almost anything as our explicit index.

Now, let's reset our indices back to integers.

In [41]:
```
df.index = np.arange(1, df.shape[0]+1, dtype='int')
```

What if we want to access any particular row (say first row)?

Let's first see for one column.

Later, we can generalise the same for the entire dataframe.

In [42]:
```
ser = df["Country"]
ser.head(20)
```

Out[42]:
```
1     Afghanistan
2     Afghanistan
3     Afghanistan
4     Afghanistan
5     Afghanistan
6     Afghanistan
7     Afghanistan
8     Afghanistan
9     Afghanistan
10    Afghanistan
11    Afghanistan
12    Afghanistan
13        Albania
14        Albania
15        Albania
16        Albania
17        Albania
18        Albania
19        Albania
20        Albania
Name: Country, dtype: object
```

We can simply use its indices much like we do in a Numpy array.

So, how will be then access the 13th element?

In [43]:
```
ser[12]
```

Out[43]:
```
'Afghanistan'
```

What about accessing a subset of rows (say 6th to 15th)?

In [44]:
```
ser[5:15]
```

Out[44]:
```
6     Afghanistan
7     Afghanistan
8     Afghanistan
9     Afghanistan
10    Afghanistan
11    Afghanistan
12    Afghanistan
13        Albania
14        Albania
15        Albania
Name: Country, dtype: object
```

This is known as `Slicing`.

Notice something different though?

- **Indexing in Series** used **explicit indices**
- **Slicing** however used **implicit indices**

Let's try the same for the dataframe.

How can we access a row in a dataframe?

In [46]:
```
df[0]
```

```
---------------------------------------------------------------------------
KeyError                                  Traceback (most recent call last)
File ~/anaconda3/lib/python3.11/site-packages/pandas/core/indexes/base.py:3
802, in Index.get_loc(self, key, method, tolerance)
   3801 try:
-> 3802     return self._engine.get_loc(casted_key)
   3803 except KeyError as err:

File ~/anaconda3/lib/python3.11/site-packages/pandas/_libs/index.pyx:138, i
n pandas._libs.index.IndexEngine.get_loc()

File ~/anaconda3/lib/python3.11/site-packages/pandas/_libs/index.pyx:165, i
n pandas._libs.index.IndexEngine.get_loc()

File pandas/_libs/hashtable_class_helper.pxi:5745, in pandas._libs.hashtabl
e.PyObjectHashTable.get_item()

File pandas/_libs/hashtable_class_helper.pxi:5753, in pandas._libs.hashtabl
e.PyObjectHashTable.get_item()

KeyError: 0

The above exception was the direct cause of the following exception:

KeyError                                  Traceback (most recent call last)
Cell In[46], line 1
----> 1 df[0]

File ~/anaconda3/lib/python3.11/site-packages/pandas/core/frame.py:3807, in
DataFrame.__getitem__(self, key)
   3805 if self.columns.nlevels > 1:
   3806     return self._getitem_multilevel(key)
-> 3807 indexer = self.columns.get_loc(key)
   3808 if is_integer(indexer):
   3809     indexer = [indexer]

File ~/anaconda3/lib/python3.11/site-packages/pandas/core/indexes/base.py:3
804, in Index.get_loc(self, key, method, tolerance)
   3802     return self._engine.get_loc(casted_key)
   3803 except KeyError as err:
-> 3804     raise KeyError(key) from err
   3805 except TypeError:
   3806     # If we have a listlike key, _check_indexing_error will raise
   3807     #  InvalidIndexError. Otherwise we fall through and re-raise
   3808     #  the TypeError.
   3809     self._check_indexing_error(key)

KeyError: 0
```

Notice that this syntax is exactly same as how we tried accessing a column.

- `df[x]` looks for column with name `x`

How can we access a slice of rows in the dataframe?

In [47]:
```
df[5:15]
```

Out[47]:

	Country	year	population	life_exp	gdp_cap
6	Afghanistan	1977	14880372	38.438	786.113360
7	Afghanistan	1982	12881816	39.854	978.011439
8	Afghanistan	1987	13867957	40.822	852.395945
9	Afghanistan	1992	16317921	41.674	649.341395
10	Afghanistan	1997	22227415	41.763	635.341351
11	Afghanistan	2002	25268405	42.129	726.734055
12	Afghanistan	2007	31889923	43.828	974.580338
13	Albania	1952	1282697	55.230	1601.056136
14	Albania	1957	1476505	59.280	1942.284244
15	Albania	1962	1728137	64.820	2312.888958

Woah, so the slicing works.

This can be a cause for confusion.

To avoid this, Pandas provides special indexers, `loc` and `iloc`

loc and iloc

1. loc

- Allows indexing and slicing that always references the explicit index.

In [51]:
```
df.loc[1]
```

Out[51]:
```
Country       Afghanistan
year                 1952
population        8425333
life_exp           28.801
gdp_cap        779.445314
Name: 1, dtype: object
```

In [52]:
```
df.loc[1:3]
```

Out[52]:

	Country	year	population	life_exp	gdp_cap
1	Afghanistan	1952	8425333	28.801	779.445314
2	Afghanistan	1957	9240934	30.332	820.853030
3	Afghanistan	1962	10267083	31.997	853.100710

Did you notice something strange here?

- The **range is inclusive** of **end point** for `loc`.
- **Row with label 3** is **included** in the result.

2. iloc

- Allows indexing and slicing that always references the implicit index.

In [53]:
```
df.iloc[1]
```

Out[53]:
```
Country       Afghanistan
year                 1957
population        9240934
life_exp           30.332
gdp_cap         820.85303
Name: 2, dtype: object
```

Will `iloc` also consider the range inclusive?

In [54]:
```
df.iloc[0:2]
```

Out[54]:

	Country	year	population	life_exp	gdp_cap
1	Afghanistan	1952	8425333	28.801	779.445314
2	Afghanistan	1957	9240934	30.332	820.853030

No, because **`iloc` works with implicit Python-style indices**.

Which one should we use?

- Generally, explicit indexing is considered to be better than implicit indexing.
- But it is recommended to always use both `loc` and `iloc` to avoid any confusions.

What if we want to access multiple non-consecutive rows at same time?

In [55]:
```
df.iloc[[1, 10, 100]]
```

Out[55]:

	Country	year	population	life_exp	gdp_cap
2	Afghanistan	1957	9240934	30.332	820.853030
11	Afghanistan	2002	25268405	42.129	726.734055
101	Bangladesh	1972	70759295	45.252	630.233627

We can just **pack the indices in `[]`** and pass it in `loc` or `iloc`.

What about negative index? Which would work between `iloc` and `loc`?

In [56]:
```
df.iloc[-1]

# Works and gives last row in dataframe
```

Out[56]:
```
Country         Zimbabwe
year                2007
population      12311143
life_exp           43.487
gdp_cap        469.709298
Name: 1704, dtype: object
```

In [57]:
```
df.loc[-1]

# Does not work
```

```
---------------------------------------------------------------------------
KeyError                                  Traceback (most recent call last)
File ~/anaconda3/lib/python3.11/site-packages/pandas/core/indexes/base.py:3
802, in Index.get_loc(self, key, method, tolerance)
   3801 try:
-> 3802     return self._engine.get_loc(casted_key)
   3803 except KeyError as err:

File ~/anaconda3/lib/python3.11/site-packages/pandas/_libs/index.pyx:138, i
n pandas._libs.index.IndexEngine.get_loc()

File ~/anaconda3/lib/python3.11/site-packages/pandas/_libs/index.pyx:165, i
n pandas._libs.index.IndexEngine.get_loc()

File pandas/_libs/hashtable_class_helper.pxi:2263, in pandas._libs.hashtabl
e.Int64HashTable.get_item()

File pandas/_libs/hashtable_class_helper.pxi:2273, in pandas._libs.hashtabl
e.Int64HashTable.get_item()

KeyError: -1

The above exception was the direct cause of the following exception:

KeyError                                  Traceback (most recent call last)
Cell In[57], line 1
----> 1 df.loc[-1]

File ~/anaconda3/lib/python3.11/site-packages/pandas/core/indexing.py:1073,
in _LocationIndexer.__getitem__(self, key)
   1070 axis = self.axis or 0
   1072 maybe_callable = com.apply_if_callable(key, self.obj)
-> 1073 return self._getitem_axis(maybe_callable, axis=axis)

File ~/anaconda3/lib/python3.11/site-packages/pandas/core/indexing.py:1312,
in _LocIndexer._getitem_axis(self, key, axis)
   1310 # fall thru to straight lookup
   1311 self._validate_key(key, axis)
-> 1312 return self._get_label(key, axis=axis)

File ~/anaconda3/lib/python3.11/site-packages/pandas/core/indexing.py:1260,
in _LocIndexer._get_label(self, label, axis)
   1258 def _get_label(self, label, axis: int):
   1259     # GH#5567 this will fail if the label is not present in the axi
s.
-> 1260     return self.obj.xs(label, axis=axis)

File ~/anaconda3/lib/python3.11/site-packages/pandas/core/generic.py:4056,
in NDFrame.xs(self, key, axis, level, drop_level)
   4054             new_index = index[loc]
   4055 else:
-> 4056     loc = index.get_loc(key)
   4058     if isinstance(loc, np.ndarray):
   4059         if loc.dtype == np.bool_:

File ~/anaconda3/lib/python3.11/site-packages/pandas/core/indexes/base.py:3
804, in Index.get_loc(self, key, method, tolerance)
   3802     return self._engine.get_loc(casted_key)
   3803 except KeyError as err:
-> 3804     raise KeyError(key) from err
   3805 except TypeError:
   3806     # If we have a listlike key, _check_indexing_error will raise
   3807     #  InvalidIndexError. Otherwise we fall through and re-raise
   3808     #  the TypeError.
```

```
   3809     self._check_indexing_error(key)

KeyError: -1
```

So, why did `iloc[-1]` worked, but `loc[-1]` didn't?

- Because **`iloc` works with positional indices, while `loc` with assigned labels**.
- `[-1]` here points to the **row at last position** in `iloc`.

Can we use one of the columns as row index?

In [58]:
```
temp = df.set_index("Country")
temp
```

Out[58]:

Country	year	population	life_exp	gdp_cap
Afghanistan	1952	8425333	28.801	779.445314
Afghanistan	1957	9240934	30.332	820.853030
Afghanistan	1962	10267083	31.997	853.100710
Afghanistan	1967	11537966	34.020	836.197138
Afghanistan	1972	13079460	36.088	739.981106
...	...	...	...	...
Zimbabwe	1987	9216418	62.351	706.157306
Zimbabwe	1992	10704340	60.377	693.420786
Zimbabwe	1997	11404948	46.809	792.449960
Zimbabwe	2002	11926563	39.989	672.038623
Zimbabwe	2007	12311143	43.487	469.709298

1704 rows × 4 columns

Note: In earlier versions of Pandas, `drop=True` has to be provided to delete the column being used as new index.

Now what would the row corresponding to index `Afghanistan` give?

In [59]:
```
temp.loc['Afghanistan']
```

Out[59]:

Country	year	population	life_exp	gdp_cap
Afghanistan	1952	8425333	28.801	779.445314
Afghanistan	1957	9240934	30.332	820.853030
Afghanistan	1962	10267083	31.997	853.100710
Afghanistan	1967	11537966	34.020	836.197138
Afghanistan	1972	13079460	36.088	739.981106
Afghanistan	1977	14880372	38.438	786.113360
Afghanistan	1982	12881816	39.854	978.011439
Afghanistan	1987	13867957	40.822	852.395945
Afghanistan	1992	16317921	41.674	649.341395
Afghanistan	1997	22227415	41.763	635.341351
Afghanistan	2002	25268405	42.129	726.734055
Afghanistan	2007	31889923	43.828	974.580338

As you can see, we got the rows all having index `Afghanistan`.

Generally, it is advisable to keep unique indices. But it also depends on the use-case.

How can we reset our indices back to integers?

In [60]:
```
df.reset_index()
```

Out[60]:

	index	Country	year	population	life_exp	gdp_cap
0	1	Afghanistan	1952	8425333	28.801	779.445314
1	2	Afghanistan	1957	9240934	30.332	820.853030
2	3	Afghanistan	1962	10267083	31.997	853.100710
3	4	Afghanistan	1967	11537966	34.020	836.197138
4	5	Afghanistan	1972	13079460	36.088	739.981106
...	...	...	...	...	...	...
1699	1700	Zimbabwe	1987	9216418	62.351	706.157306
1700	1701	Zimbabwe	1992	10704340	60.377	693.420786
1701	1702	Zimbabwe	1997	11404948	46.809	792.449960
1702	1703	Zimbabwe	2002	11926563	39.989	672.038623
1703	1704	Zimbabwe	2007	12311143	43.487	469.709298

1704 rows × 6 columns

Notice that it's creating a new column `index`.

How can we reset our index without creating this new column?

In [61]:
```
df.reset_index(drop=True) # by using drop=True we can prevent creation of a
```

Out[61]:

	Country	year	population	life_exp	gdp_cap
0	Afghanistan	1952	8425333	28.801	779.445314
1	Afghanistan	1957	9240934	30.332	820.853030
2	Afghanistan	1962	10267083	31.997	853.100710
3	Afghanistan	1967	11537966	34.020	836.197138
4	Afghanistan	1972	13079460	36.088	739.981106
...	...	...	...	...	...
1699	Zimbabwe	1987	9216418	62.351	706.157306
1700	Zimbabwe	1992	10704340	60.377	693.420786
1701	Zimbabwe	1997	11404948	46.809	792.449960
1702	Zimbabwe	2002	11926563	39.989	672.038623
1703	Zimbabwe	2007	12311143	43.487	469.709298

1704 rows × 5 columns

Great!

Now let's do this in place.

In [62]:
```
df.reset_index(drop=True, inplace=True)
```

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

Out[63]:

	Country	year	population	life_exp	gdp_cap
0	Afghanistan	1952	8425333	28.801	779.445314
1	Afghanistan	1957	9240934	30.332	820.853030
2	Afghanistan	1962	10267083	31.997	853.100710
3	Afghanistan	1967	11537966	34.020	836.197138
4	Afghanistan	1972	13079460	36.088	739.981106
...	...	...	...	...	...
1699	Zimbabwe	1987	9216418	62.351	706.157306
1700	Zimbabwe	1992	10704340	60.377	693.420786
1701	Zimbabwe	1997	11404948	46.809	792.449960
1702	Zimbabwe	2002	11926563	39.989	672.038623
1703	Zimbabwe	2007	12311143	43.487	469.709298

1704 rows × 5 columns

In [ ]:
```

```