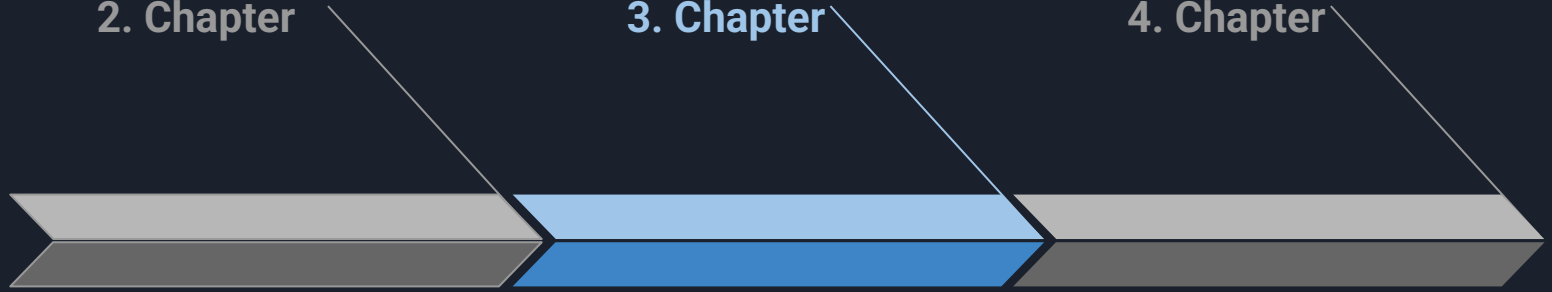
Introduction to Data Science with Python

Chapter 3

Topics of the course



Python Fundamentals

Basic concepts, Variables, basic data structures, functions

Data Wrangling & Simple visualizations

How to process data with pandas and visualize it with matplotlib

Visualizations & Modelling

More plots with matplotlib and seaborn and an introduction to modelling

What you learn in this Chapter...

... how to use Python libraries

... work with data in a DataFrame

... filter, merge and group your data

... visualize data with simple plots

Data Wrangling & Visualization

Libraries

Libraries

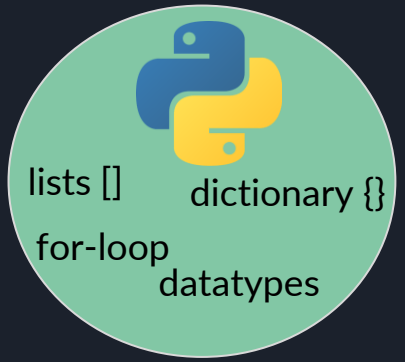
- A collection of functions is bundled in a **library**
- we import these libraries and can use the defined functions
- Some libraries come with a Python installation, some need to be installed

... for plotting and visualization

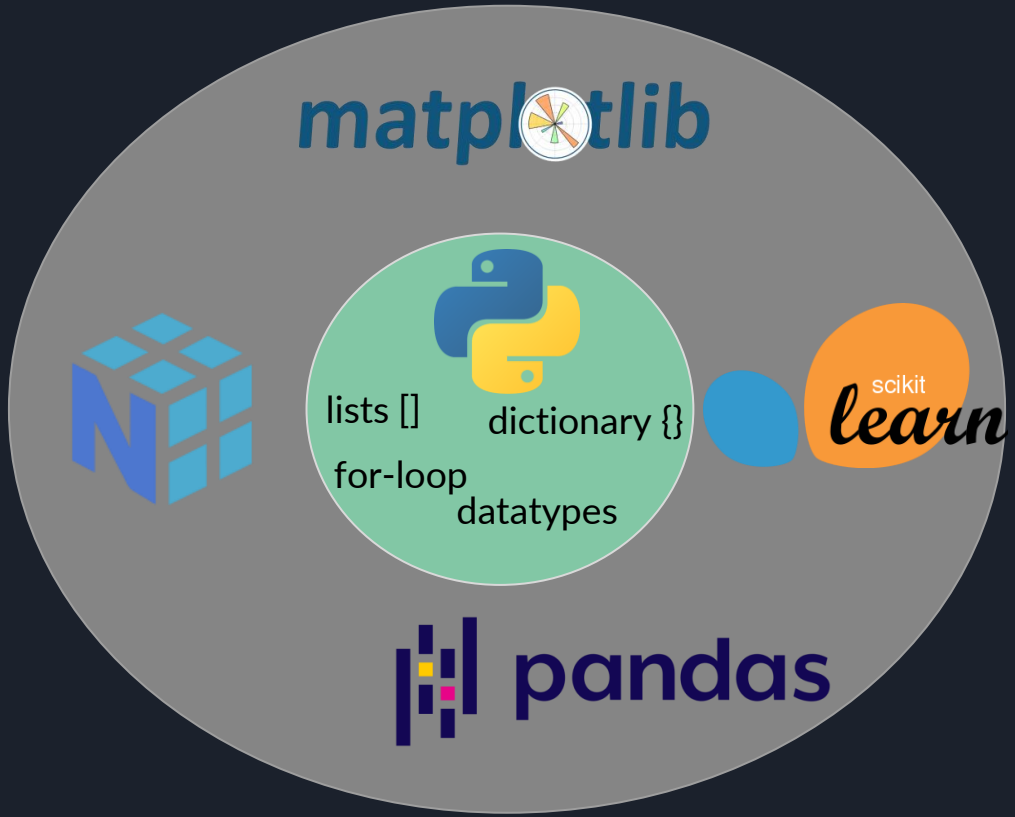
... for working with tabular data (Excel-files, csv-files,...)

... creating machine learning models

Libraries



Libraries


matplotlib
lists []
dictionary {}
for-loop
datatypes
scikit
learn
pandas

Function & Methods

Functions

```
a = function_name(parameter)
```

Function & Methods

Functions

```
a = function_name(parameter)
```

Methods

```
a = "a string!"
a = a.upper() # ‘A STRING!’
```

Import Libraries

```
import library

a = library.function_name()
```

Import Libraries

```
import library as l

a = l.function_name()
```

Data Wrangling & Visualization

Arrays with Numpy

NumPy - library

- Library for scientific computing
- Work with lists, matrices or higher dimensional structures
- NumPy lists have much more functionality than usual lists

```
import numpy as np

a = np.array([1,2,3,4])
```

NumPy - library

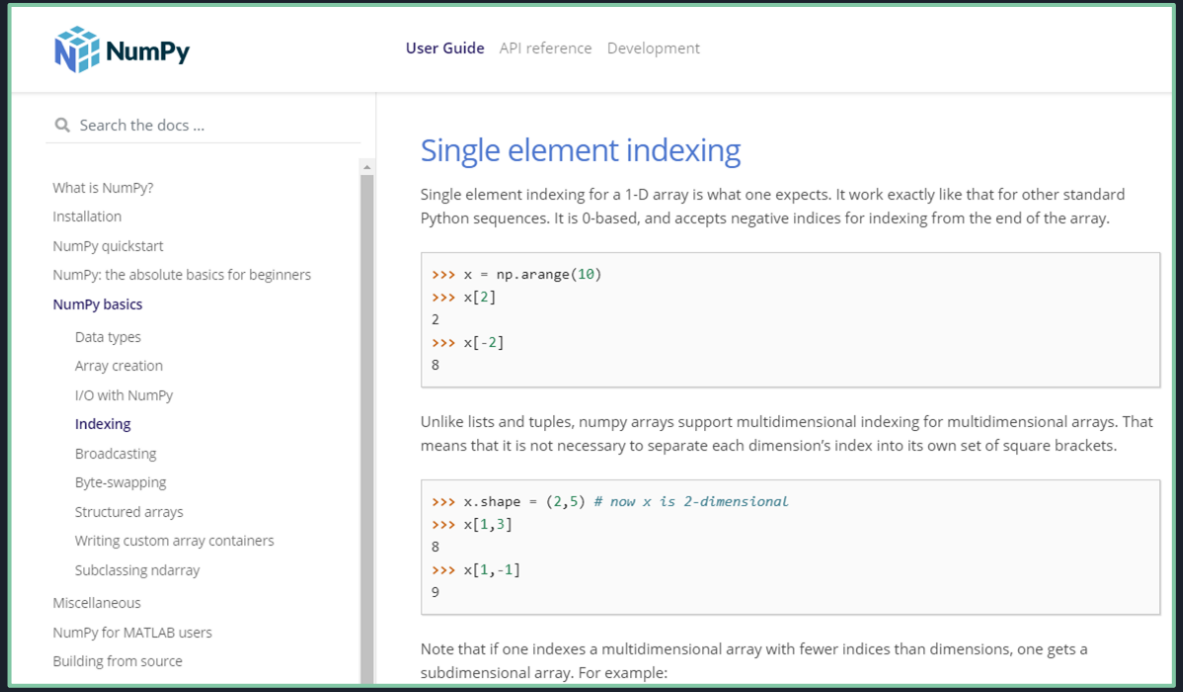
- Library for scientific computing
- Work with lists, matrices or higher dimensional structures
- NumPy lists have much more functionality than usual lists

```
import numpy as np

a = np.array([1,2,3,4])
a.sum() # 10
a.mean() # 2.5
a.std() # 1.118...
```

Documentation

- Explanations to the methods and functions
- Often include examples and tutorials
- https://numpy.org/doc/



NumPy - Append

```
import numpy as np

a = np.array([1,2,3,4])
np.append(a, [5,6,7]) # array([1, 2, 3, 4, 5, 6, 7])
```

NumPy - Append

```
import numpy as np

a = np.array([1,2,3,4])
np.append(a, [5,6,7]) # array([1, 2, 3, 4, 5, 6, 7])
a = np.append(a, [5,6,7])
```

Compute with arrays - Broadcasting

```
import numpy as np
a = np.array([1,2,3])
a * 2 # array([2, 4, 6])
a ** 2 # array([1, 4, 9])
a - 1 # array([0, 1, 2])
```

Compute with arrays

```
import numpy as np
a = np.array([1,2,3])
b = np.array([1,1,1])
a + b  # array([2, 3, 4])
```

Indexing

```
import numpy as np

a = np.array([1,2,3,4])
a[0:2] # array([1,2])
```

Boolean Indexing

```
import numpy as np

a = np.array([1,2,3,4])
a[[True,True,False,False]] # array([1,2])
```

Boolean Indexing

```
import numpy as np

a = np.array([1,2,3,4])
a <= 2 # [True, True, False, False]
```

Boolean Indexing

```
import numpy as np

a = np.array([1,2,3,4])
a <= 2 # [True, True, False, False]
a[a<=2] # array([1,2])
```

Exercise 1

```
import numpy as np

a = np.array([1,2,3,4])
a = np.append(a, [5,6,7])# [1,2,3,4,5,6,7]
a[a<=2] # [1,2] (boolean indexing)
a.sum() # 28
```

Data Wrangling & Visualization

Tabular Data with Pandas

pandas - library

```
import pandas as pd

data = {
"Name":["Clara","Tom","Sarah","John"],
"Age" :[20,24,19,21]}

df = pd.DataFrame(data)
```

	Name	Age
0	Clara	20
1	Tom	24
2	Sarah	19
3	John	21

DataFrame - data structure

Read data

- Pandas can read data from files
- Various data formats possible

```
df = pd.read_csv('path_to_file')
df = pd.read_excel('path_to_file')
df = pd.read_sql_table('postgres://db')
```

First look at the data

```
df.head()
```

	id	price	neighbourhood_group_cleansed	latitude
0	28684898	$50.00	Neukölln	52.473978
1	22607348	$10.00	Treptow - Köpenick	52.468095
2	21019199	$35.00	Neukölln	52.481810
3	21919556	$99.00	Pankow	52.537269
4	4820648	$39.00	Friedrichshain-Kreuzberg	52.491483

```
df.describe()
```

	id	price	latitude	longitude	bathrooms
count	1.353100e+04	13531.000000	13531.000000	13531.000000	13508.000000
mean	1.573089e+07	70.082625	52.509956	13.405871	1.095203
std	8.580394e+06	255.451132	0.030773	0.058517	0.335469
min	2.695000e+03	0.000000	52.346203	13.103557	0.000000
25%	8.041528e+06	30.000000	52.489082	13.374950	1.000000
50%	1.697254e+07	45.000000	52.509229	13.416764	1.000000
75%	2.264464e+07	70.000000	52.532808	13.439258	1.000000
max	2.986735e+07	9000.000000	52.651670	13.721671	8.500000

Select Data

Select data in a DataFrame

idx	Name	Age
0	Clara	20
1	Tom	24
2	Sarah	19
3	John	21

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

Select data in a DataFrame

idx	Name	Age
0	Clara	20
1	Tom	24
2	Sarah	19
3	John	21

```
df = pd.DataFrame(data)
df["Name"]
```

Select data in a DataFrame

idx	Name	Age
0	Clara	20
1	Tom	24
2	Sarah	19
3	John	21

```
df = pd.DataFrame(data)
df.iloc[0:3]
```

Add data to a DataFrame

idx	Name	Age	Grade
0	Clara	20	1
1	Tom	24	2
2	Sarah	19	3
3	John	21	4

```
df["Grade"] = [1,2,3,4]
```

Compute with data in a DataFrame

idx	Name	Age	Grade
0	Clara	20	2
1	Tom	24	3
2	Sarah	19	4
3	John	21	5

```
df["Grade"] = df["Grade"] + 1
```

Drop data

idx	Name	Age	Grade
0	Clara	20	1
1	Tom	24	2
2	Sarah	19	3
3	John	21	4

```
# Drop column
df = df.drop(column="Grade")
```

Drop data

idx	Name	Age	Grade
2	Sarah	19	3
3	John	21	4

```
# Drop column
df = df.drop(column="Grade")
# Drop row
df.drop([0,1], inplace=True)
```

Filter data

Filter data - select a subset of the data

idx	Name	Age	Grade
0	Clara	20	2
2	John	21	5

```
keep_rows = [True, False,
                 True,False]

df[keep_rows]
```

Filter data - select a subset of the data

idx	Name	Age	Grade
0	Clara	20	2
1	Tom	24	3
2	Sarah	19	4
3	John	21	5

```
df["Age"] <= 20
→ [True, False, True, False]
```

Filter data - select a subset of the data

idx	Name	Age	Grade
0	Clara	20	2
2	John	21	5

```
df[ df["Age"] <= 20 ]
```

```
[True, False, True, False]
```

Filter data - select a subset of the data

idx	Name	Age	Grade
0	Clara	20	2

```
df[
    (df["Age"] <= 20) &
    (df["Grade"] < 3)
  ]
```

Filter data - select a subset of the data

idx	Name	Age	Grade
0	Clara	20	2
2	Sarah	19	4

```
df[
    (df["Age"] == 20) |
    (df["Grade"] == 4)
  ]
```

Combine filtering with other methods

idx	Name	Age	Grade
0	Clara	20	2
2	John	21	5

```
df[df["Age"] <= 20]
```

This is again a DataFrame

Combine filtering with other methods

idx	Name	Age	Grade
0	Clara	20	2
2	John	21	5

```
df[df["Age"]<=20]["Age"].mean()
```

Exercise 2

```
import pandas as pd

df = pd.DataFrame(data) # create dataframe
df['new_column'] = [1,2,3]
df.sort_values(by='column_name') # sort
df[df['age']<=20] # filter data
```

Pandas methods

Apply pandas methods

- Pandas has large amount of commonly used methods
- Can be applied to single column or whole data frame

```
df["Grade"].mean()
df["Grade"].std()
df["Grade"].sum()
```

Often used methods

```
df["Grade"].mean()

df["Grade"].sum()

df["Grade"].value_counts()

df.sort_values(by="Grade")

df.groupby(by="Grade").sum()

df1.merge(df2)

df.drop(colums=["Grade"])

df["Grade"].replace(5,"Failed")
```

Group-By

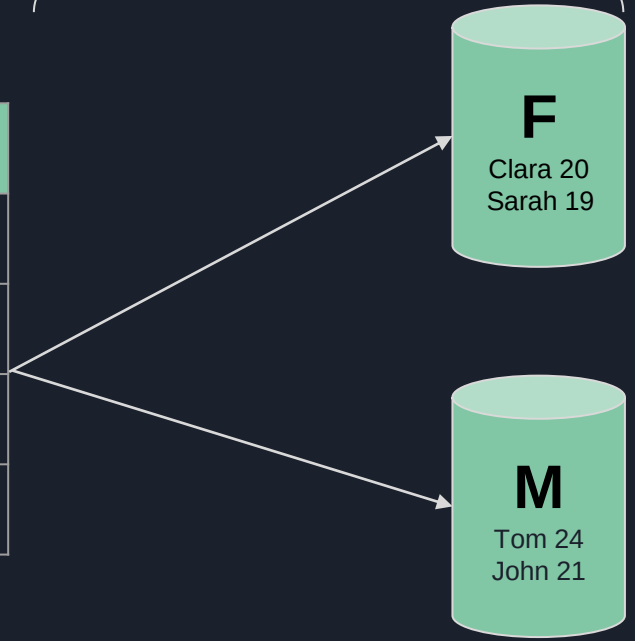
idx	Name	Age	Gender
0	Clara	20	F
1	Tom	24	M
2	Sarah	19	F
3	John	21	M

What is the average age per gender?

Group-By

```
df.groupby(by='Gender').mean()
```

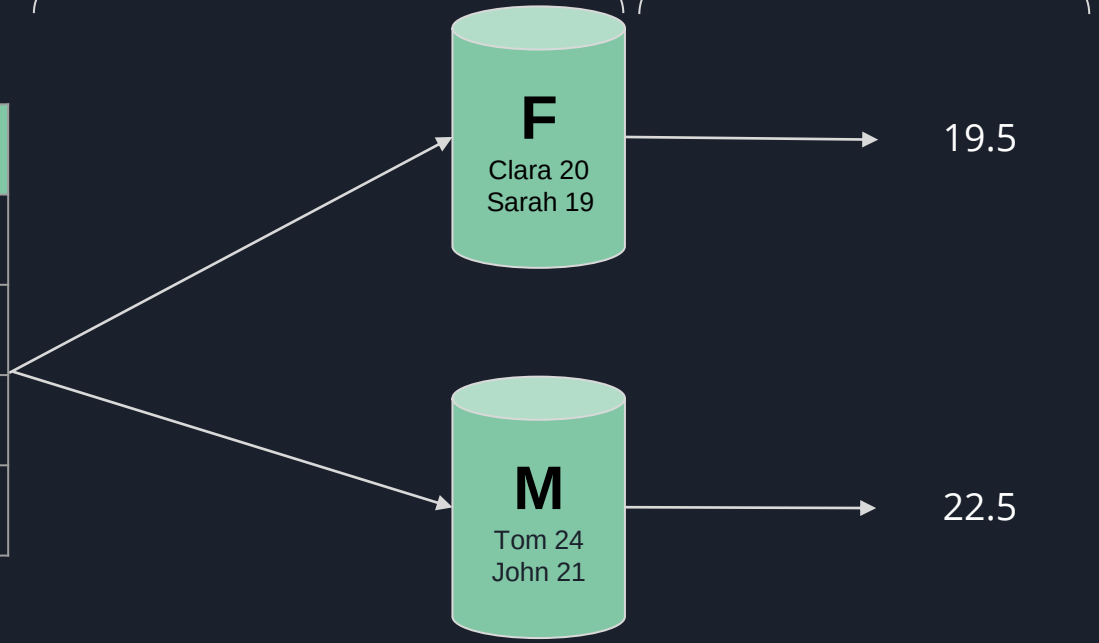
idx	Name	Age	Gender
0	Clara	20	F
1	Tom	24	M
2	Sarah	19	F
3	John	21	M



Group-By

```
df.groupby(by='Gender').mean()
```

idx	Name	Age	Gender
0	Clara	20	F
1	Tom	24	M
2	Sarah	19	F
3	John	21	M



Merge DataFrame's

Name	Age	Grade
Clara	20	2
Tom	24	3
Sarah	19	4

Name	Subject
Sarah	Physics
Tom	Politics
John	English

Merge DataFrame's

Name	Age	Grade
Clara	20	2
Tom	24	3
Sarah	19	4

Name	Subject
Sarah	Physics
Tom	Politics
John	English

Name	Age	Grade	Subject
Tom	24	3	Politics
Sarah	19	4	Physics

Merge DataFrame's

Name	Age	Grade
Clara	20	2
Tom	24	3
Sarah	19	4

```
df1.merge(df2, on='Name')
```

Name	Subject
Sarah	Physics
Tom	Politics
John	English

Name	Age	Grade	Subject
Tom	24	3	Politics
Sarah	19	4	Physics

Merge DataFrame's

Name	Age	Grade
Clara	20	2
Tom	24	3
Sarah	19	4

```
df1.merge(df2,how='left',
on='Name')
```

Name	Subject
Sarah	Physics
Tom	Politics
John	English

Name	Age	Grade	Subject
Tom	24	3	Politics
Sarah	19	4	Physics
Clara	20	2	-

Exercise 3

```
import pandas as pd

df = df.groupby(by='column_name')
df = df.merge(df2,on='column_name',how='left')
```

Data Wrangling & Visualization

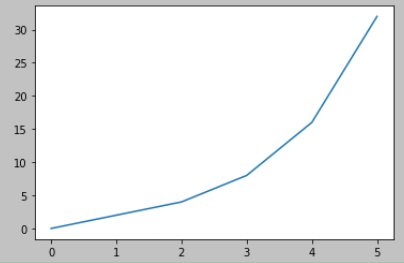
Visualizations with Matplotlib

matplotlib - library

- data visualization tool
- generate highly customizable plots
- good integration with pandas

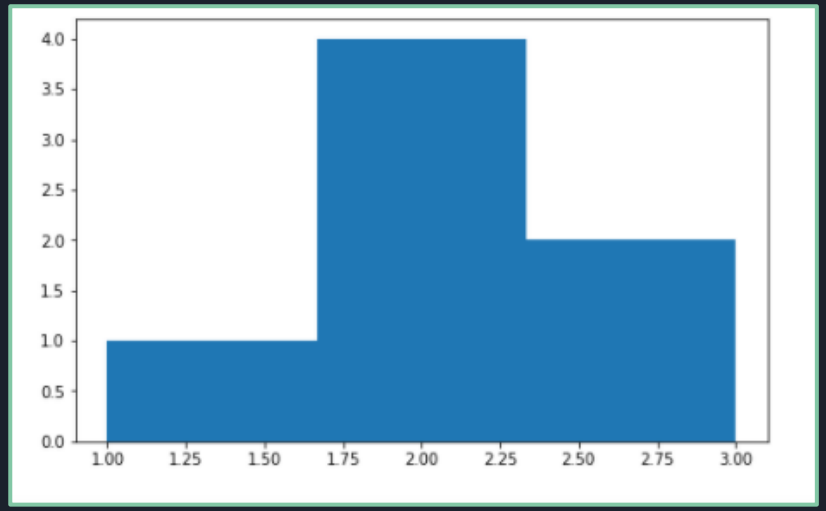
```
import matplotlib.pyplot as plt
x = [0,1,2,3,4,5]
y = [0,2,4,8,16,32]
plt.plot(x,y)
```

Plot:



Histogram

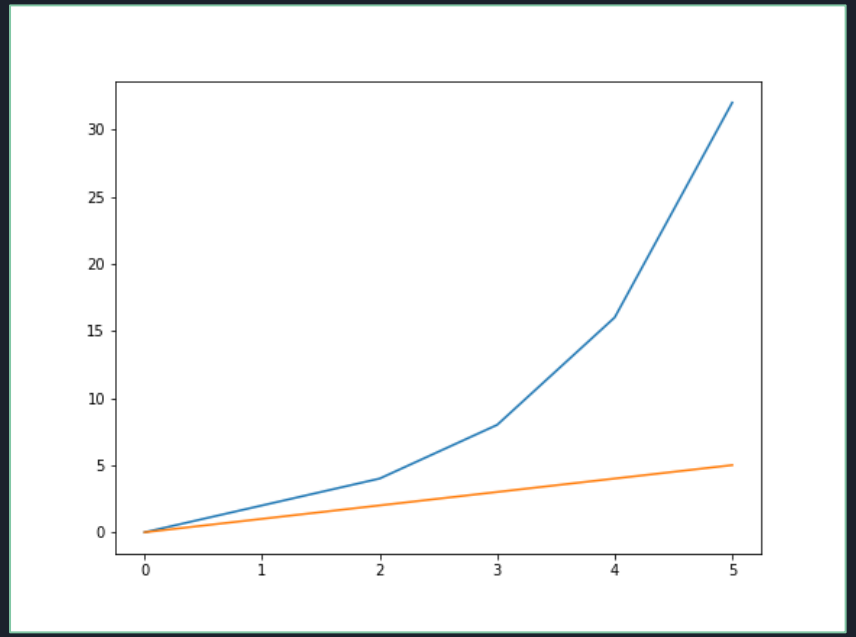
```
import matplotlib.pyplot as plt
x = [1,2,2,2,2,3,3]
plt.hist(x, bins=3)
```



Customize plots

```
import matplotlib.pyplot as plt
x = [0,1,2,3,4,5]
y = [0,2,4,8,16,32]
y2 = [0,1,2,3,4,5]

plt.plot(x,y)
plt.plot(x,y2)
```

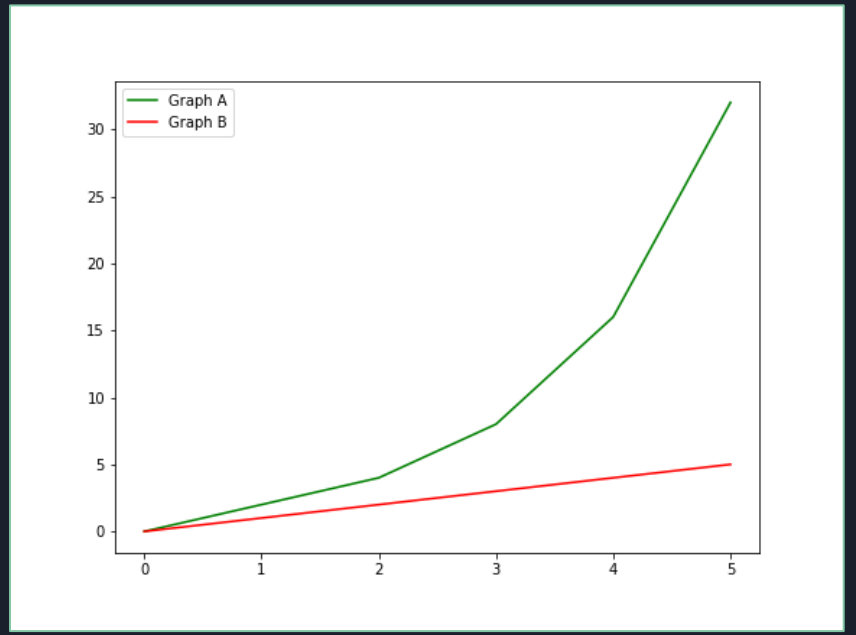


Customize plots

```
import matplotlib.pyplot as plt
x = [0,1,2,3,4,5]
y = [0,2,4,8,16,32]
y2 = [0,1,2,3,4,5]

plt.plot(x,y, color='green', label='Graph A')
plt.plot(x,y2, color='red', label='Graph B')

plt.legend()
```

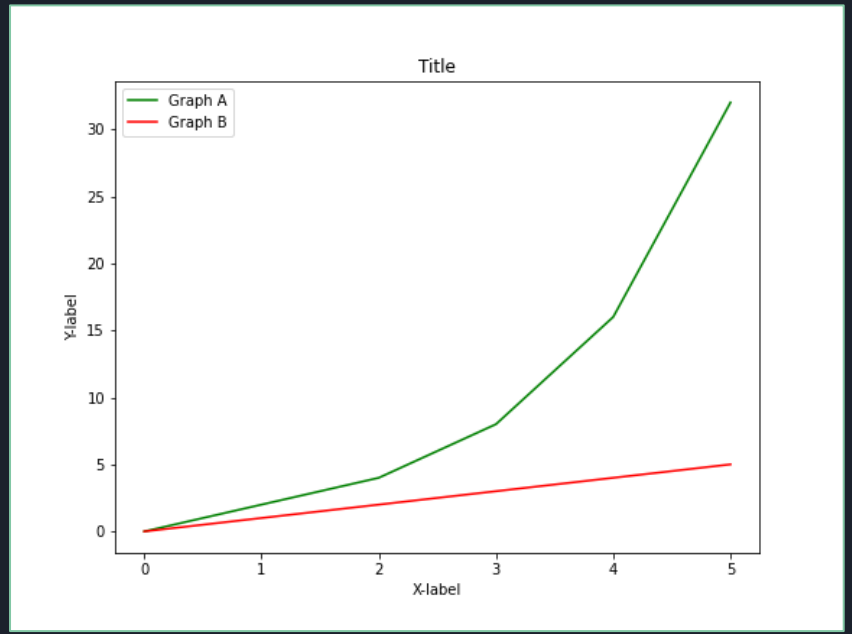


Customize plots

```
import matplotlib.pyplot as plt
x = [0,1,2,3,4,5]
y = [0,2,4,8,16,32]
y2 = [0,1,2,3,4,5]

plt.plot(x,y, color='green', label='Graph A')
plt.plot(x,y2, color='red', label='Graph B')

plt.legend()
plt.xlabel("X-label")
plt.ylabel("Y-label")
plt.title("Title")
```

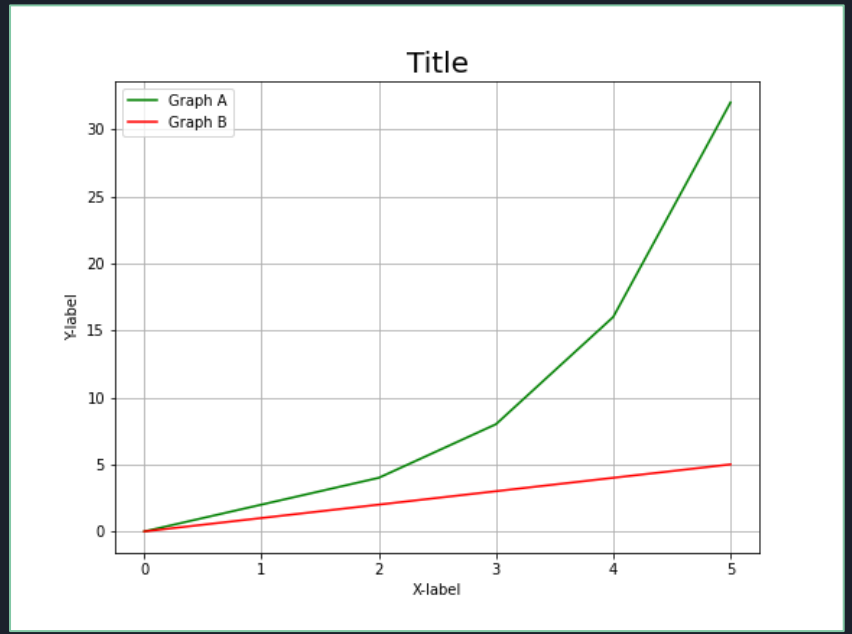


Customize plots

```
import matplotlib.pyplot as plt
x = [0,1,2,3,4,5]
y = [0,2,4,8,16,32]
y2 = [0,1,2,3,4,5]

plt.plot(x,y, color='green', label='Graph A')
plt.plot(x,y2, color='red', label='Graph B')

plt.legend()
plt.xlabel("X-label")
plt.ylabel("Y-label")
plt.title("Title",
{'fontname':'DejaVu Sans', 'size':'20'})
plt.grid()
```



pandas & matplotlib

- Pandas and matplotlib work very well together
- We can pass columns of a DataFrame to matplotlib

```
import matplotlib.pyplot as plt
df = pd.DataFrame(data)
plt.hist(df["Age"])
```

Exercise 4

```
import matplotlib.pyplot as plt
df = pd.DataFrame(data)
plt.hist(df["Age"])
```

Data Wrangling & Visualization

Clean Data with Pandas

Clean data

Data comes often in an untidy form, therefore some data cleaning is necessary

Name	Town
Clara	Frankfurt a.M.
Sarah	Frankfurt am Main
John	Berlin

```
df1['Town'].str.replace(
                'a.M.',
                'am Main', inplace=True)
```

Clean data

Data comes often in an untidy form, therefore some data cleaning is necessary

Name	Subject
Clara	Physics
Sarah	physics
John	Math

```
df1['Subject'].str.lower(inplace=True)
```

Working with dates

What kind of data type is this : `"27-03-2021"` ?

a) integer b) float c) string d) date

Transform string to datetime object

```
df['Birthday'] = pd.to_datetime(df['Birthday'])
```

Name	Birthday
Clara	“20/10/1995”
Sarah	“10/01/1999”
John	“05/03/2001”

Transform string to datetime object

```
df['Birthday'] = pd.to_datetime(df['Birthday'], format="%d/%m/%y")
```

Name	Birthday
Clara	“20/10/1995”
Sarah	“10/01/1999”
John	“05/03/2001”

Transform string to datetime object

```
df['Birthday'] = pd.to_datetime(df['Birthday'], format="%m-%d-%y")
```

Name	Birthday
Clara	“10-10-1995”
Sarah	“10-01-1999”
John	“05-03-2001”

Transform string to datetime object

```
df['day'] = df['Birthday'].dt.day
df['weekday'] = df['Birthday'].dt.weekday
df['month'] = df['Birthday'].dt.month
```

Name	Birthday	day	weekday	month
Clara	“10-10-1995”	10	1	10
Sarah	“10-01-1999”	1	4	10
John	“05-03-2001”	3	3	5

Set date as index

date	City	Temperature
“20-04-2021”	Frankfurt	10
“20-04-2021”	Berlin	11
“20-04-2021”	Munich	12
“21-04-2021”	Frankfurt	11
“21-04-2021”	Berlin	13
“21-04-2021”	Munich	14
“22-04-2021”	Frankfurt	9
“21-04-2021”	Berlin	10

```
df = df.set_index(['date'])
```