COP 3035

Intro Programming in Python

Summer 2024

Lecture 21 – part 1

Lab 10 (Optional)
Homework 7 – 07/29/24
Exam 4 – 08/02/24

Lecture 21 – part 2

Review

Review

Integration Exercise

Python Modules

Python Packages

Create your own module

Python Modules

- A **module** is a file containing Python definitions and statements.
- The file name is the module name with the suffix **.py** added.
- Modules are used to organize code logically by grouping related functions, classes, and variables. This makes the code easier to understand and use.
- Modules provide their own namespaces, which helps avoid naming conflicts between identifiers.

module_name.py

Basic Import syntax:

```
import module_name
```

Selective Import syntax:

```
from module_name import function_name
```

Alias Import syntax:

```
import module_name as mn
```

```
from module_name import function_name as fn
```

Creating Your Own Modules

- Simply save your code in a **`.py`** file.
- This file can then be imported into other Python scripts.
- Use the dot notation (**`module_name.function_name`**) to access functions and variables defined in the module.
- Use docstrings **(”””` text `”””**) to document the module, classes and functions.

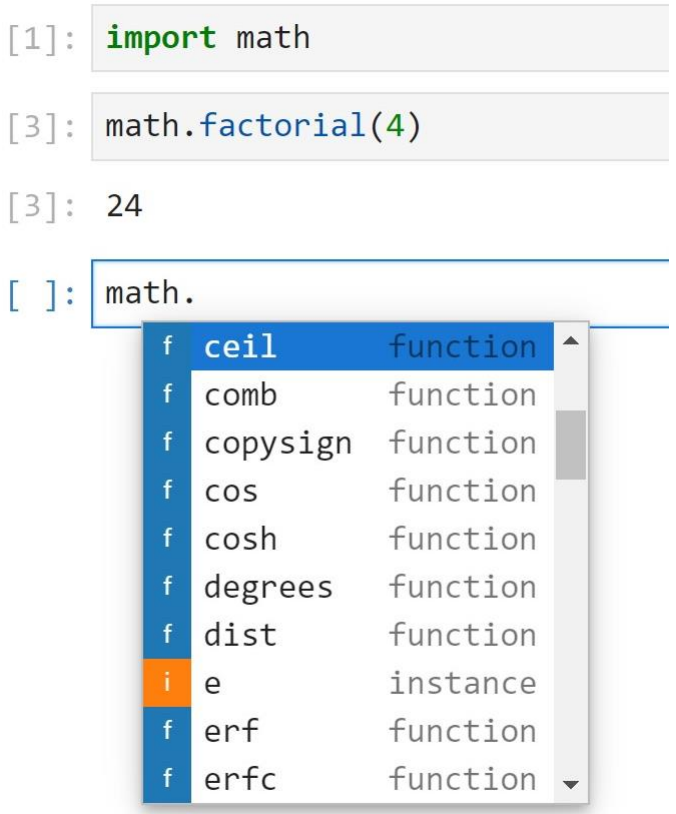
The Python Standard Library

https://docs.python.org/3/library/index.html

Python comes with a rich standard library, which is a collection of modules that provides access to system functionality and standardized solutions.

Module	Description
os	Offers functions to interact with the operating system, such as file and directory operations, executing commands, others.
sys	Provides access to some variables and functions that interact with the Python interpreter, allowing manipulation of the runtime environment.
datetime	For manipulating dates and times, calculating differences, and formatting.
math	Mathematical functions, including trigonometric, logarithmic, and more.
random	Used for generating pseudo-random numbers for various distributions and choosing randomly from sequences.
json	Supports encoding and decoding JSON data, crucial for web data interchange and configuration files.
re	Supports regular expressions for advanced string manipulation and pattern matching.

Example:



Python packages

A module is a single file containing Python code, whereas a package is a collection of modules that are organized in a directory hierarchy.

Parameter	Module	Package
Definition	It can be a simple Python file (.py extension) that contains collections of functions and global variables.	A package is a collection of different modules with an __init__.py file.
Purpose	Code organization	Code distribution and reuse
Organization	Code within a single file	Related modules in a directory hierarchy
Sub-modules	None	Multiple sub-modules and sub-packages
Required Files	Only Python file (.py format)	__init__.py file and additional Python files
How to Import	import module_name	import package_name.module_name or from package_name import module_name
Example	math, random, os, datetime, csv	Numpy, Pandas, Matplotlib, django

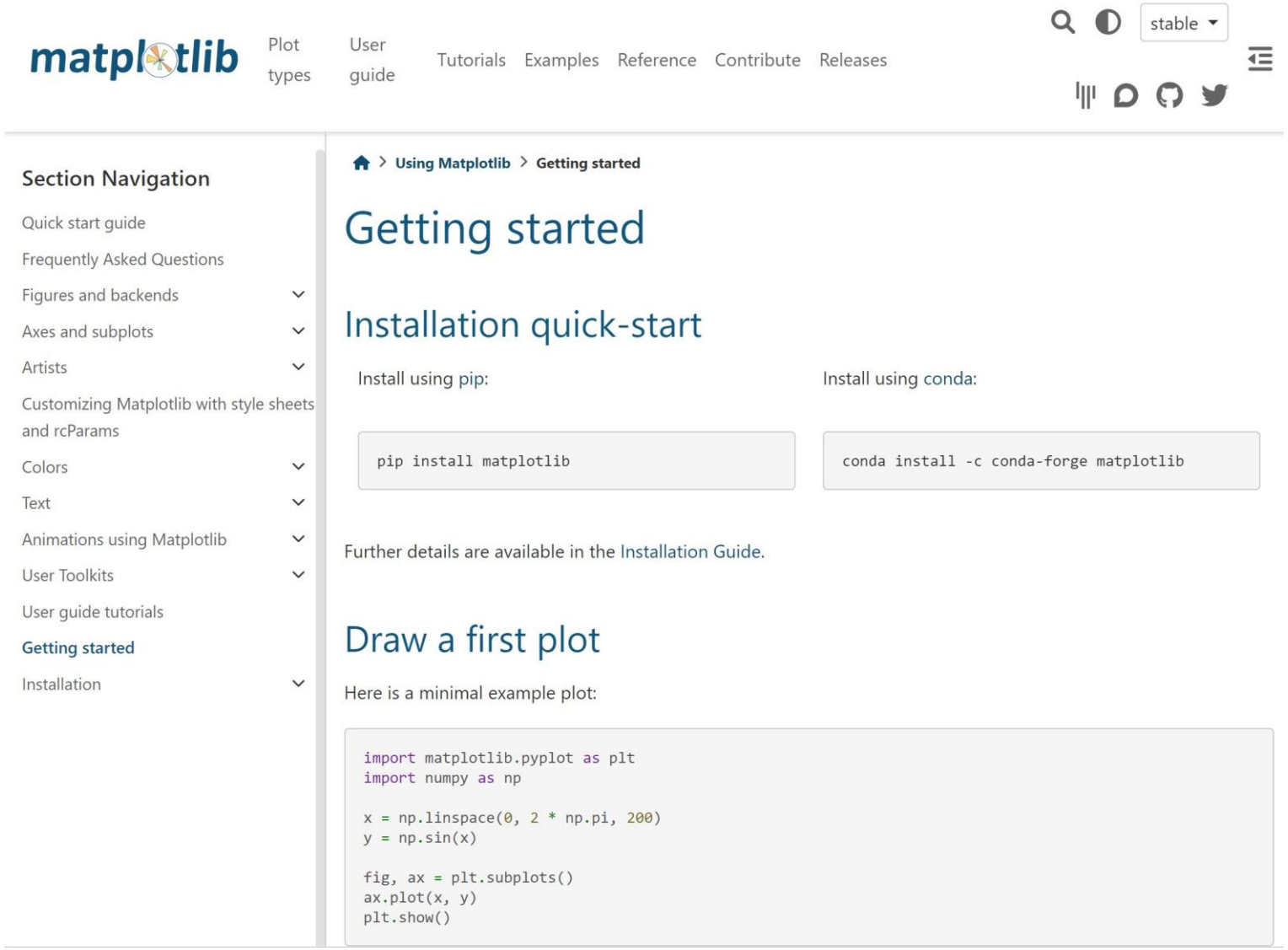
Lecture 21 – part 3

Matplotlib

Matplotlib:
A comprehensive library for creating static, animated, and interactive visualizations in Python.

Installation:
```
pip install matplotlib
```

Importing:
```
import matplotlib.pyplot as plt
```



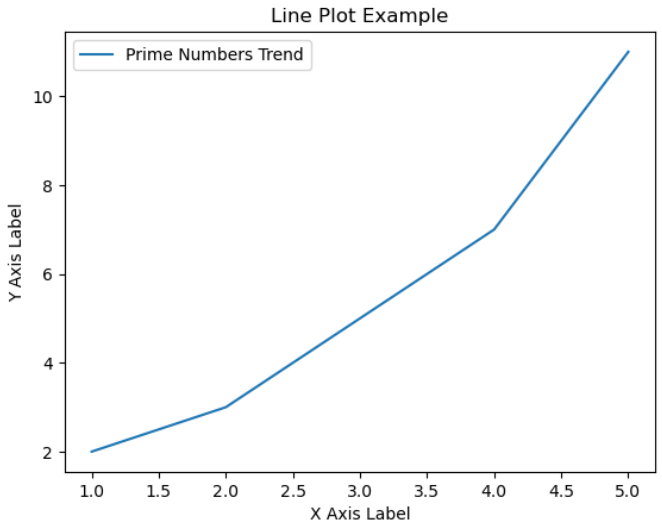
https://matplotlib.org/stable/users/getting_started/

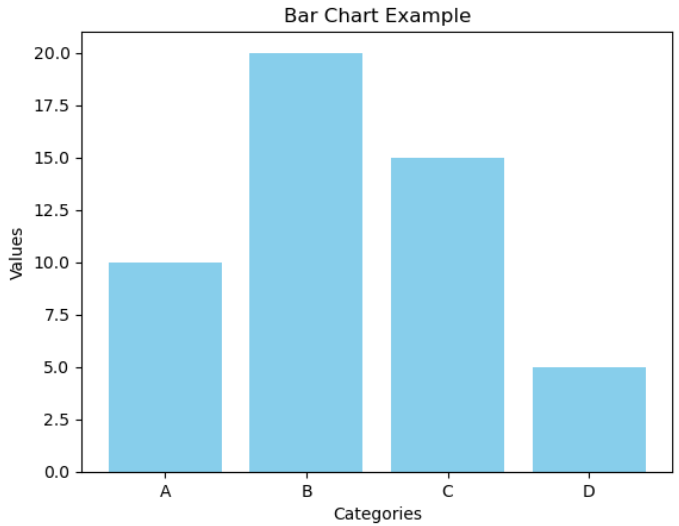
Basic plotting

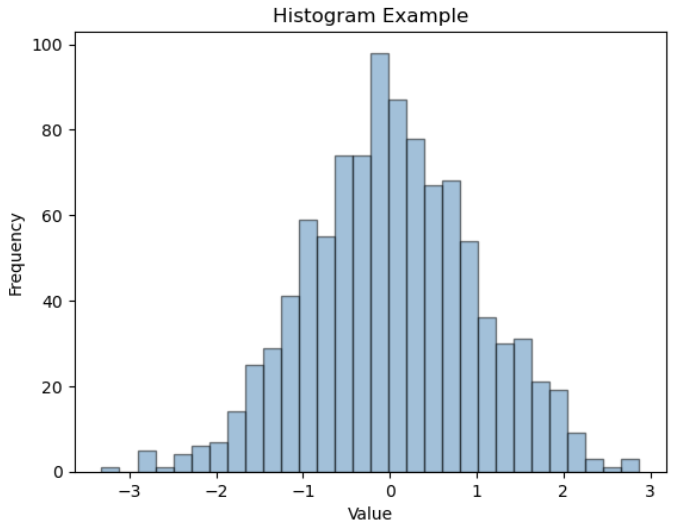
Line Plot : Basic syntax and customization (color, linestyle, marker).

Bar Chart: Comparing data side-by-side.

Histogram: Visualizing distributions.







https://matplotlib.org/stable/users/explain/quick_start.html

matplotlib.pyplot.plot()

The matplotlib.pyplot.plot() function is quite flexible, and its syntax can vary depending on how you want to customize your plot.

Syntax:

```
plot([x], y, [fmt], *, data=None, **kwargs)
plot([x], y, [fmt], [x2], y2, [fmt2], ..., **kwargs)
```

x, y: These are arrays or sequences of values. x is optional; if not provided, the default will be range(len(y)).

fmt: A format string, optional, that specifies color, marker, and line type in a shorthand form. For example, **'ro-'** means red circles connected by lines.

NOTE: The ****kwargs** parameter lets you pass in numerous other options to customize markers, lines, and more.

Common Parameters

data:	An optional parameter that allows specifying the data source (Dictionary).
color:	Specifies the color of the line. You can use named colors, hex codes, or RGB/A tuples.
label:	Sets the label for this line, which will appear in the legend.
linewidth or **lw**:	Sets the width of the line.
markersize or **ms**:	Determines the size of the markers.
linestyle or **ls**:	Defines the style of the line, such as solid, dashed, or none.
marker:	Chooses the marker style for the points, like circles, squares, etc.

```
plt.plot(y)     # Assumes x as range(len(y))
plt.plot(x, y)  # Plots y vs x
plt.plot(x, y, 'bo-')  # Blue circles with solid lines
plt.plot(x, y, color='green', marker='o', linestyle='dashed’,
         linewidth=2, markersize=12)
```

Line Styles

Symbol	Name
-	Solid
--	Dashed
-.	Dash-dot
:	Dotted
None	No line
''	No line

Markers

Symbol	Name
.	Point
,	Pixel
o	Circle
v	Triangle Down
^	Triangle Up
<	Triangle Left
>	Triangle Right
1	Tri Down
2	Tri Up
3	Tri Left
4	Tri Right

Symbol	Name
8	Octagon
s	Square
p	Pentagon
*	Star
h	Hexagon1
H	Hexagon2
+	Plus
x	X
D	Diamond
d	Thin Diamond
`	`
_	Hline

color = ‘cyan’
color=‘c’
color=‘#00FFFF’
color=(0,1,1)

Color

Color	Short Name	Hex Code	RGB Tuple (*)
Black	k	#000000	(0, 0, 0)
White	w	#FFFFFF	(255, 255, 255)
Red	r	#FF0000	(255, 0, 0)
Green	g	#008000	(0, 128, 0)
Blue	b	#0000FF	(0, 0, 255)
Cyan	c	#00FFFF	(0, 255, 255)
Magenta	m	#FF00FF	(255, 0, 255)
Yellow	y	#FFFF00	(255, 255, 0)
Light Blue	-	#ADD8E6	(173, 216, 230)
Orange	-	#FFA500	(255, 165, 0)
Purple	-	#800080	(128, 0, 128)
Brown	-	#A52A2A	(165, 42, 42)
Pink	-	#FFC0CB	(255, 192, 203)
Gray	-	#808080	(128, 128, 128)
Lime	-	#00FF00	(0, 255, 0)

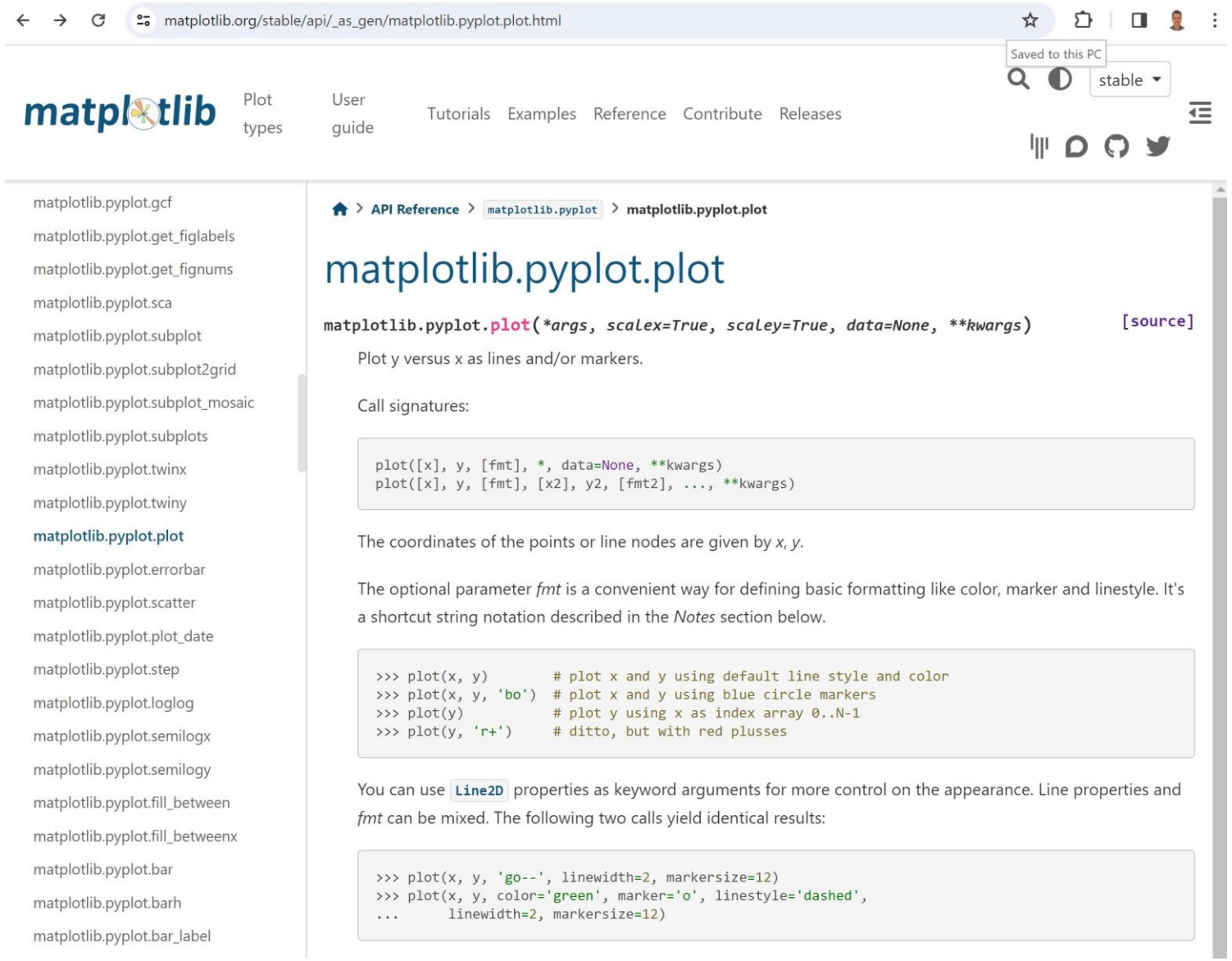
* Note: You need to convert values to [0,1] by dividing by 255.

Example using the data parameter:

```
import matplotlib.pyplot as plt

# Sample data as a dictionary
data = {
    'x': range(1, 11),
    'y1': [1, 2, 3, 4, 5, 6, 7, 8, 9, 10],
    'y2': [10, 9, 8, 7, 6, 5, 4, 3, 2, 1]
}

# Plotting with explicit formatting
plt.plot('x', 'y1', data=data, marker='o', color='red', linestyle='-', label='Ascending')
plt.plot('x', 'y2', data=data, marker='^', color='blue', linestyle='--', label='Descending')

plt.legend()
plt.show()
```

API Reference:

https://matplotlib.org/stable/api/_as_gen/matplotlib.pyplot.plot.html



Exercises

1. Draw a plot of a simple list [1,2,3,4,5]. Then add a title and a grid.
2. Draw a plot using two lists X and Y. Add title, grid, axis titles and a line label.
3. Draw three plots for $y_1=x$, $y_2=x^2$ and $y_3=x^3$, for the first 50 numbers. Use different colors and markers.
4. Generate a line plot with three different mathematical functions:

   y1 = sin(x) ,

   y2 = cos(x) and

   y3 = 2sin(x)cos(x),

   for x ranging from 0 to 2π.

   Use different line styles and colors for each function. Include a title and legends. Label the axis.

5. Complete the tutorial for matplotlib.pyplot at: https://matplotlib.org/stable/tutorials/pyplot.html#sphx-glr-tutorials-pyplot-py

Lecture 21 – part 4

NumPy

What is NumPy ?

- **NumPy** stands for Numerical Python.
- It's a library for Python that supports **large, multi-dimensional arrays and matrices**.
- Provides a wide range of **mathematical functions** to operate on these arrays **efficiently**.
- **Simplifies** complex numerical operations, making code more readable and concise.
- Works well with **other libraries** in the Python data ecosystem (e.g., pandas, matplotlib).
- **Common Use Cases:** Data analysis, Machine Learning, Image processing, simulations

Installation:

```
pip install numpy
```

Importing:

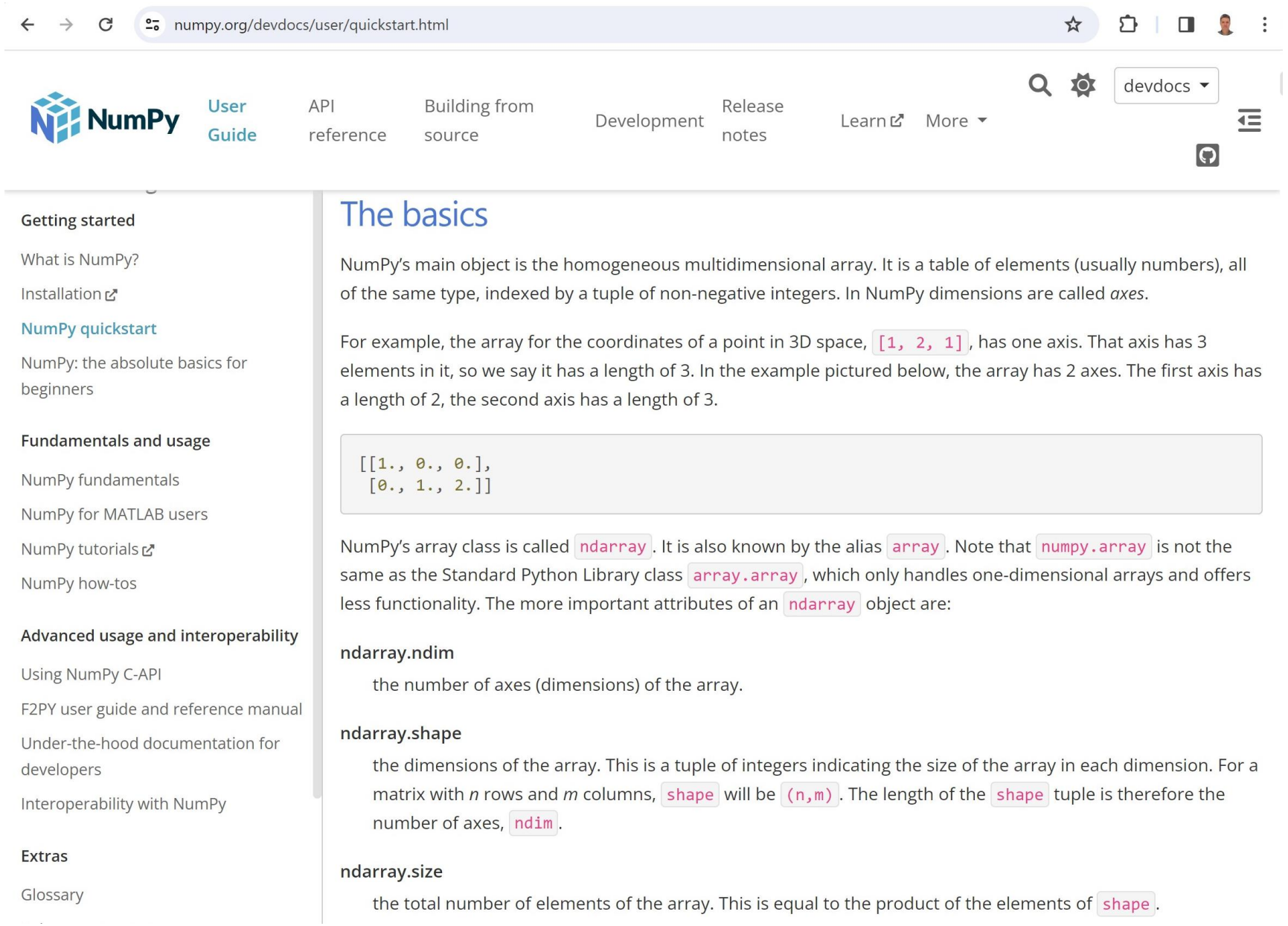
```
import numpy as np
```

Creating an array:

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

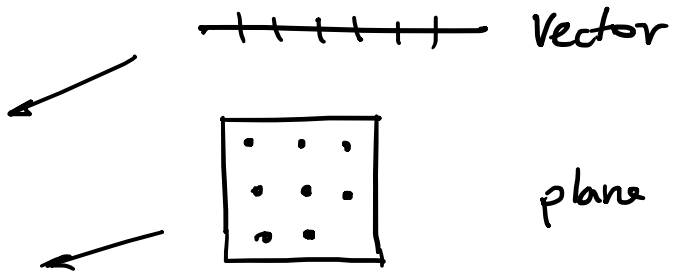
NumPy's array class is called **ndarray**

https://numpy.org/devdocs/user/quickstart.html

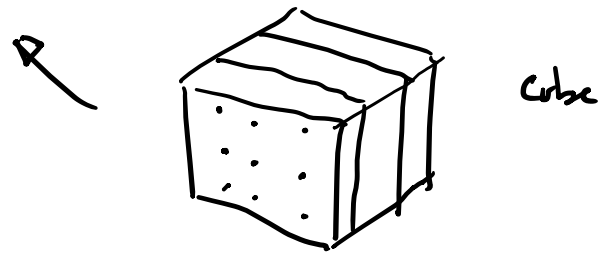


NumPy dimensions

- NumPy dimensions are called ***axes***




```
one_d_array = np.array([1, 2, 3, 4, 5])

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

three_d_array = np.array([[[1, 2, 3], [4, 5, 6]], [[7, 8, 9], [10, 11, 12]], [[13, 14, 15], [16, 17, 18]]])
```



Basics

Feature	Description	Example Code
np.array	Creates an array.	A = np.array([1, 2, 3])
.ndim	Number of array dimensions.	A.ndim
.shape	Dimensions of the array.	A.shape
.size	Number of elements in the array.	A.size
np.zeros	Creates an array filled with zeros.	np.zeros((2, 3))
np.ones	Creates an array filled with ones.	np.ones((3, 3))
np.arange	Creates an array with a range of values.	np.arange(0, 10, 2)
np.linspace	Creates an array with evenly spaced values.	np.linspace(0, 1, 5)

Operations

Feature	Description	Example Code
-	Subtraction element-wise.	A - B
**	Exponentiation element-wise.	A ** 2
*	Multiplication element-wise.	A * B
<	Element-wise comparison.	A < B
.dot()	Dot product of two arrays.	A.dot(B) or np.dot(A, B)

Math

Feature	Description	Example Code
np.add()	Element-wise addition.	np.add(A, B)
np.exp()	Exponential of all elements.	np.exp(A)
np.sqrt()	Square root of each element.	np.sqrt(A)
np.sin()	Sine of each element.	np.sin(A)
np.cos()	Cosine of each element.	np.cos(A)

Indexing and Slicing

Feature	Description	Example Code
Single element indexing	Access a single element by its position.	arr[2] or arr[2, 3]
Slice along one dimension	Select a range of elements from an array.	arr[0:5] or arr[:5]
Slice along two dimensions	Select a rectangle of elements.	arr[1:4, 0:3]
Stride for slicing	Select elements with a step size between them.	arr[::2] or arr[0:5:2]
Negative slicing	Use negative indices to slice from the end of the array.	arr[-3:] or arr[1:-1]
Boolean indexing	Select elements based on a boolean condition.	arr[arr > 5]
Fancy indexing	Index with integer arrays.	arr[[1, 3, 4]] or arr[[1, 2], [3, 4]]
Mixing integer and slice	Combine integer indexing and slicing.	arr[1, :2] or arr[2:3, :1]
Ellipsis (...)	Used to replace multiple colons.	arr[..., 1] (same as arr[:, 1])

NumPy Array Manipulations

.ravel()

- Flattens an array into a contiguous 1D array.
- Returns a view of the original array whenever possible, making it memory efficient.
- Changes to the returned array may affect the original array.
- Example: `flattened_array = arr.ravel()`

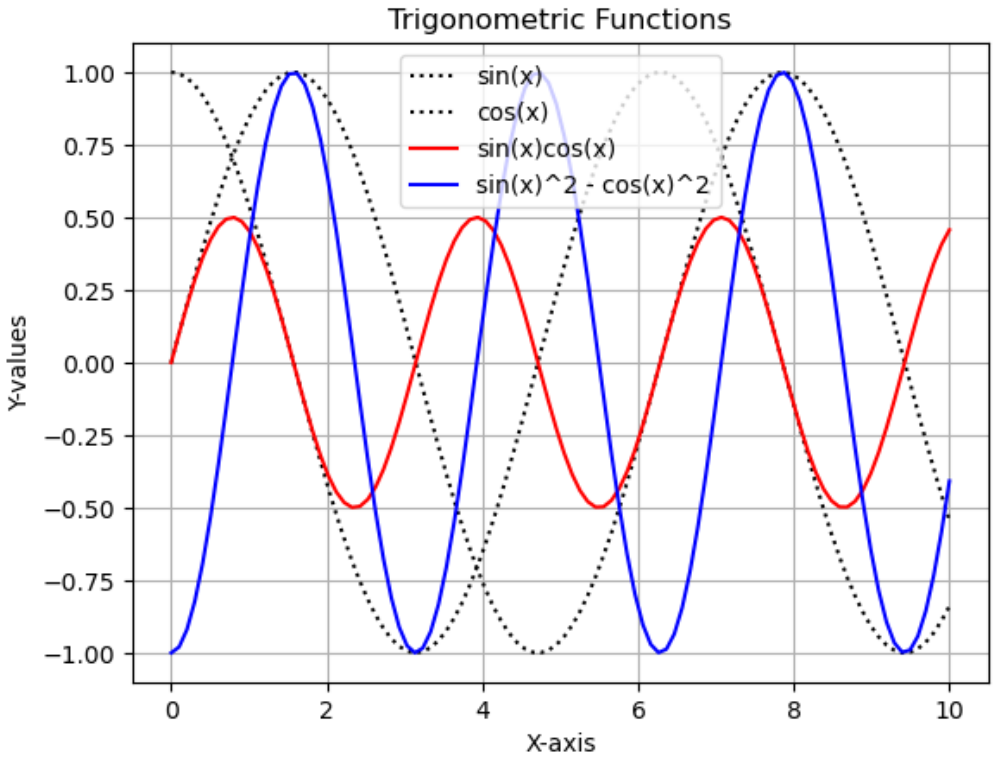
.reshape()

- Gives a new shape to an array without changing its data.
- Returns a new array with the specified shape.
- Can return a view or a copy, depending on the memory layout.
- Use -1 to automatically calculate the size of one dimension.
- Example: `reshaped_array = arr.reshape(2, 6)`

.resize()

- Alters the size and shape of an array in-place.
- Can expand or shrink the array; new elements are filled with zeros.
- Does not return a value; modifies the original array.
- Example: `arr.resize((2, 6))`

Example: Using Numpy, Matplotlib and Pandas



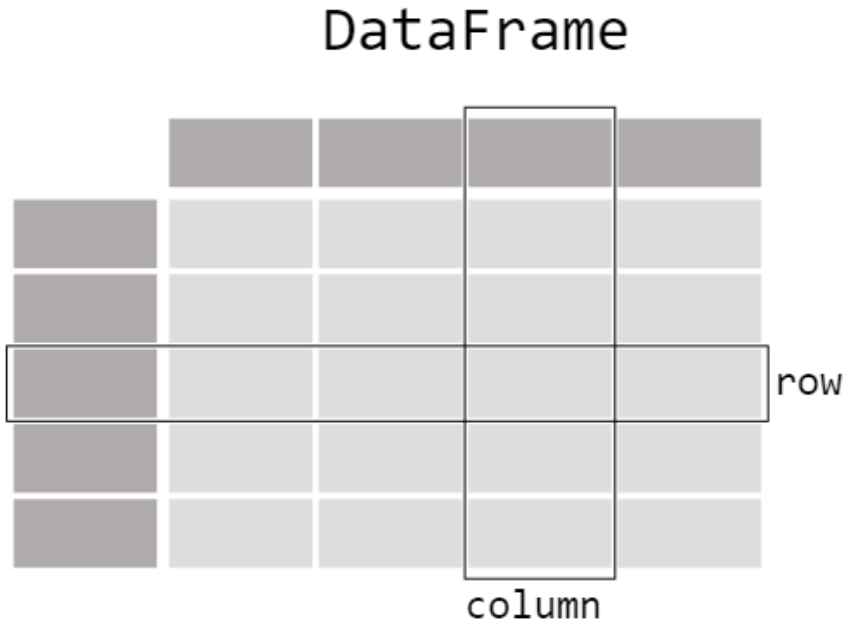
Lecture 21 – part 5

Pandas

Pandas

Pandas is a fast, powerful, flexible and easy to use open-source data analysis and manipulation tool, built on top of the Python programming language.

- Provides essential data structures like **DataFrame** and **Series** for efficient data manipulation and analysis.
- Supports **various file formats** including CSV, Excel, and SQL, facilitating easy data reading and writing.
- Offers **tools** for handling missing data, merging, joining, and filtering datasets effectively.
- Includes **robust features for time series** data manipulation such as resampling and frequency conversion.
- Backed by a **strong community** with extensive documentation, making it a reliable choice for data scientists and analysts.

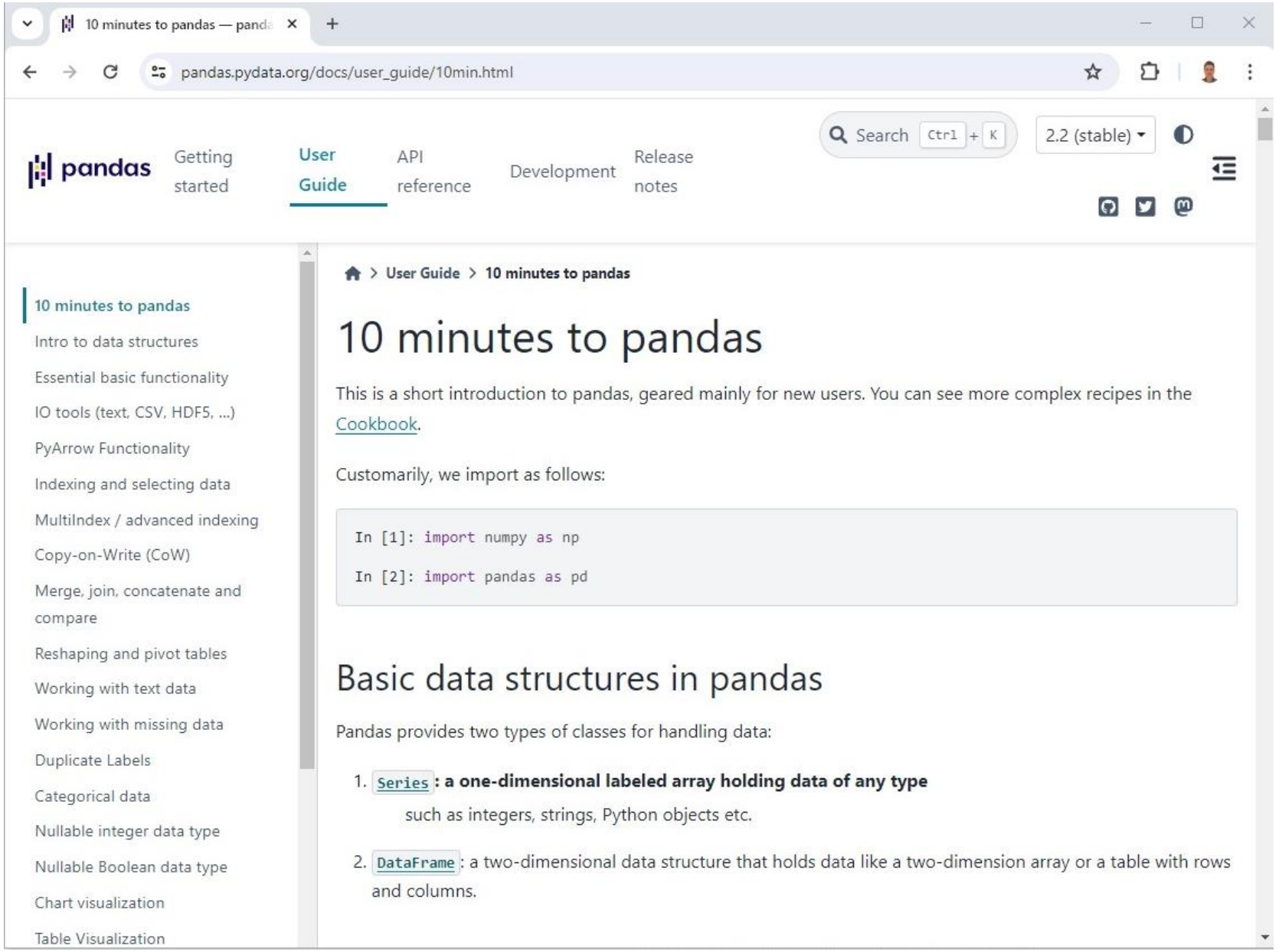


Installation

```
pip install pandas
```

Import

```
import pandas as pd
```



https://pandas.pydata.org/docs/user_guide/10min.html