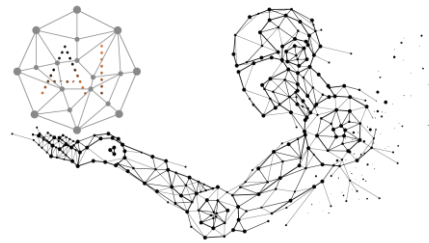
Applied Machine Learning

Chapter 1- Introduction to Python

دانشگاه تربیت مدرس
Tarbiat Modares University

Hossein Homaei
Department of Electrical & Computer Engineering

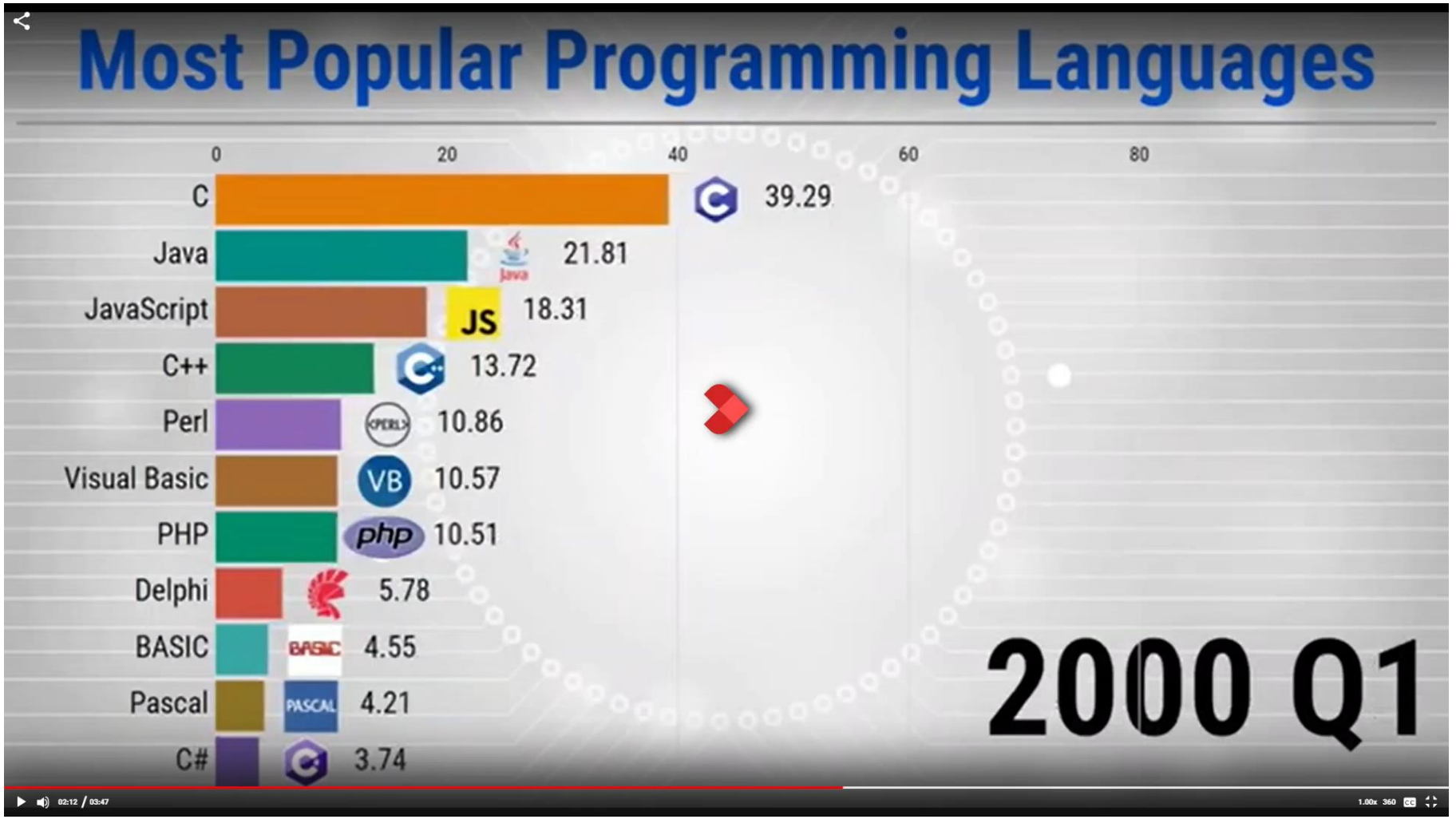


What is Python?

- High-level Interpreted programming language
- Created in 1991 by Guido van Rossum
- Supports
  - Object-oriented programming
- Dynamic typing
- Multipurpose
  - Backend web apps
  - Desktop apps
  - Games
  - Task automation
  - Machine learning and Data science
  - …

"I was looking for a hobby programming project to keep me occupied during a slow work week around Christmas. I used my home computer to write an interpreter for a new scripting language, which would become known as Python."
Guido van Rossum

Why Python?


Most Popular Programming Languages
0
20
40
60
80
C
39.29
Java
21.81
JavaScript
18.31
C++
13.72
Perl
10.86
Visual Basic
10.57
PHP
10.51
Delphi
5.78
BASIC
4.55
Pascal
4.21
C#
3.74
2000 Q1
02:12 / 03:47
1.00x 360

...Why Python?

- Well-connected and supportive community.
- Efficient language
  - Do more in fewer lines of code
  - Write clean code (because of Python's syntax)
  - Easy to read, debug, and extend programs
  - Like natural human-language
- Easy to learn yet powerful
- Comes with a large library of useful modules
  - Motto of the Python programming lanhuage: Batteries Included

```
print("Hello world.")
```

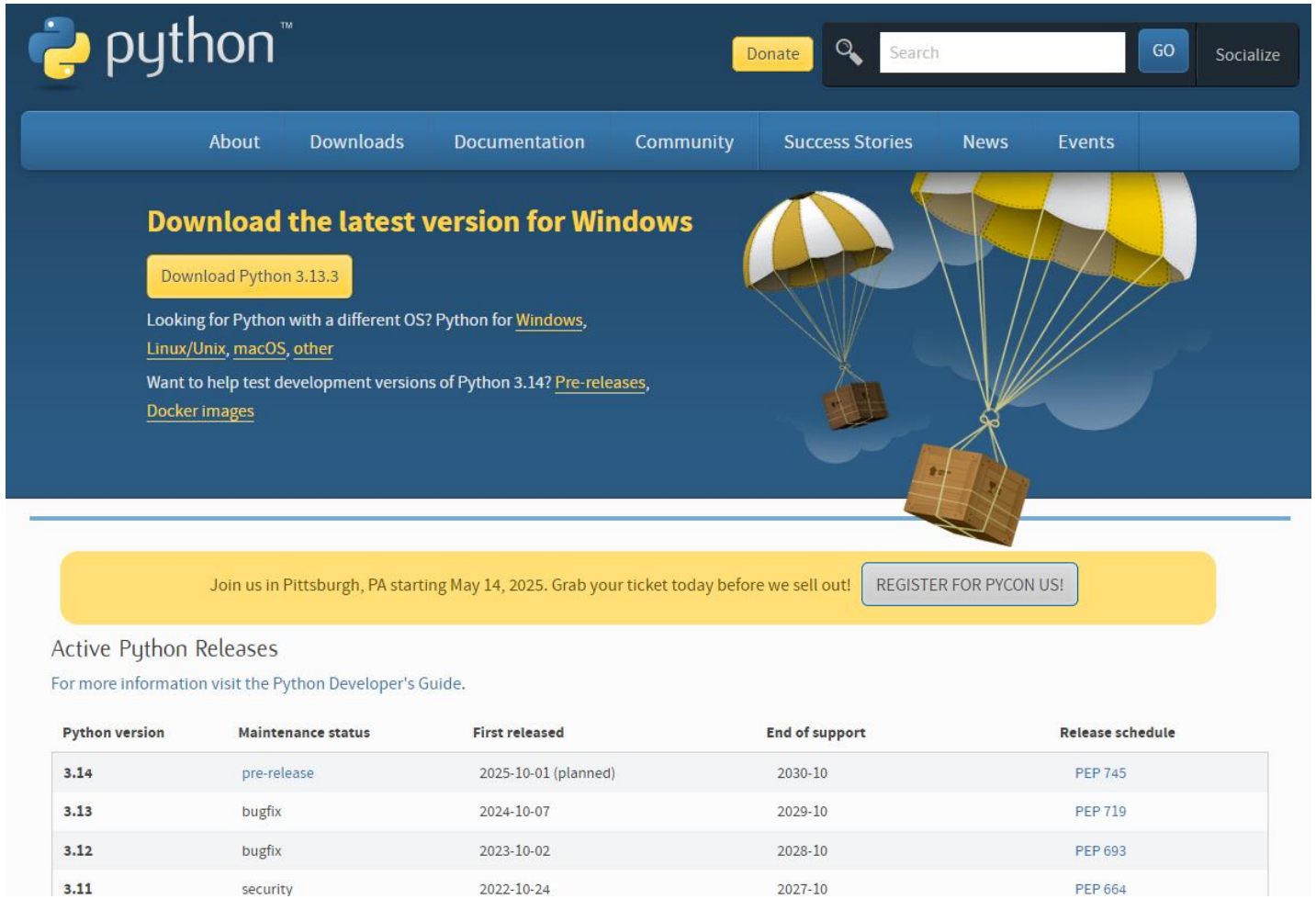
```
public class HelloWorld {
    public static void main (String[]args) {
      System.out.println.("Hello world");
    }
}
```

- Is used heavily in scientific fields for academic research and applied work.

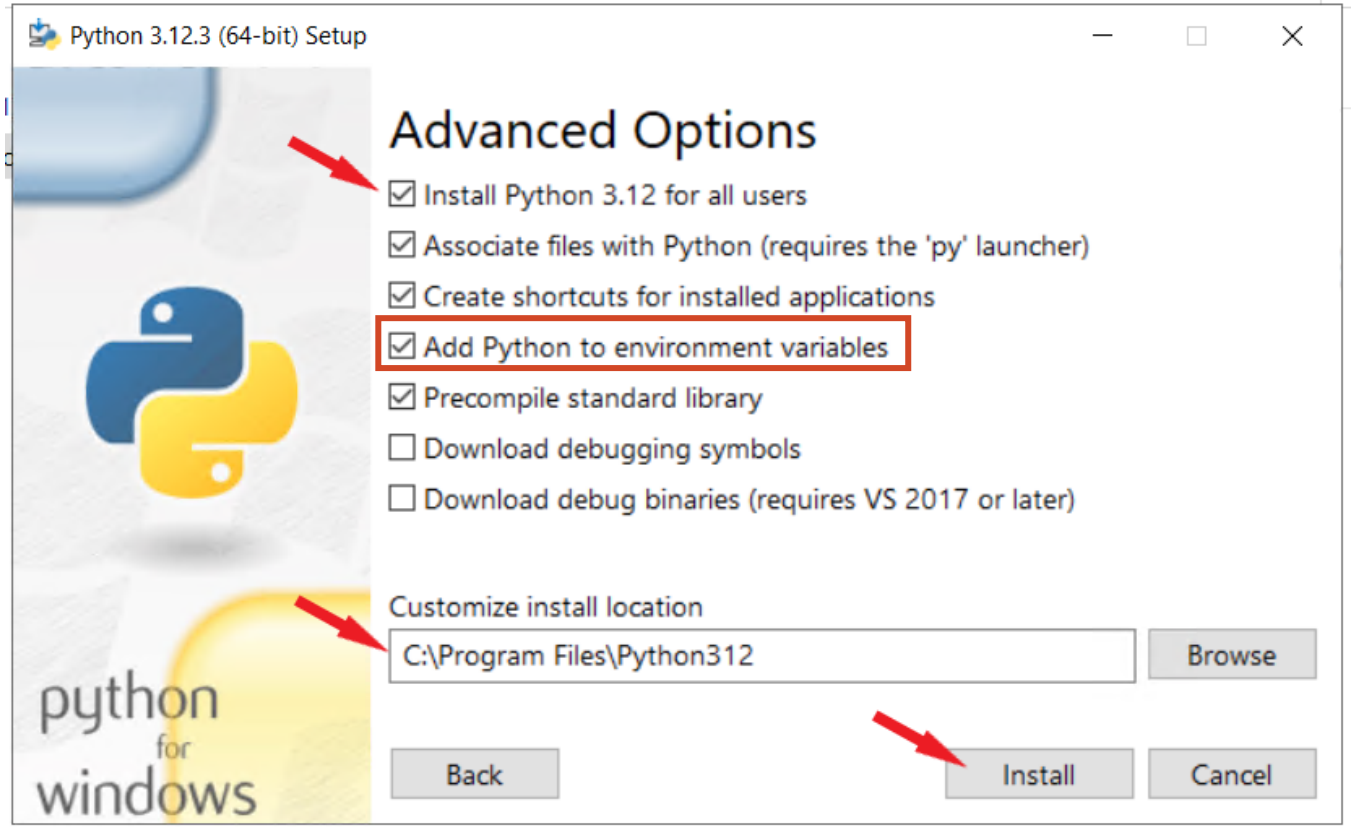
Set Up The Programming Environment

Install Python

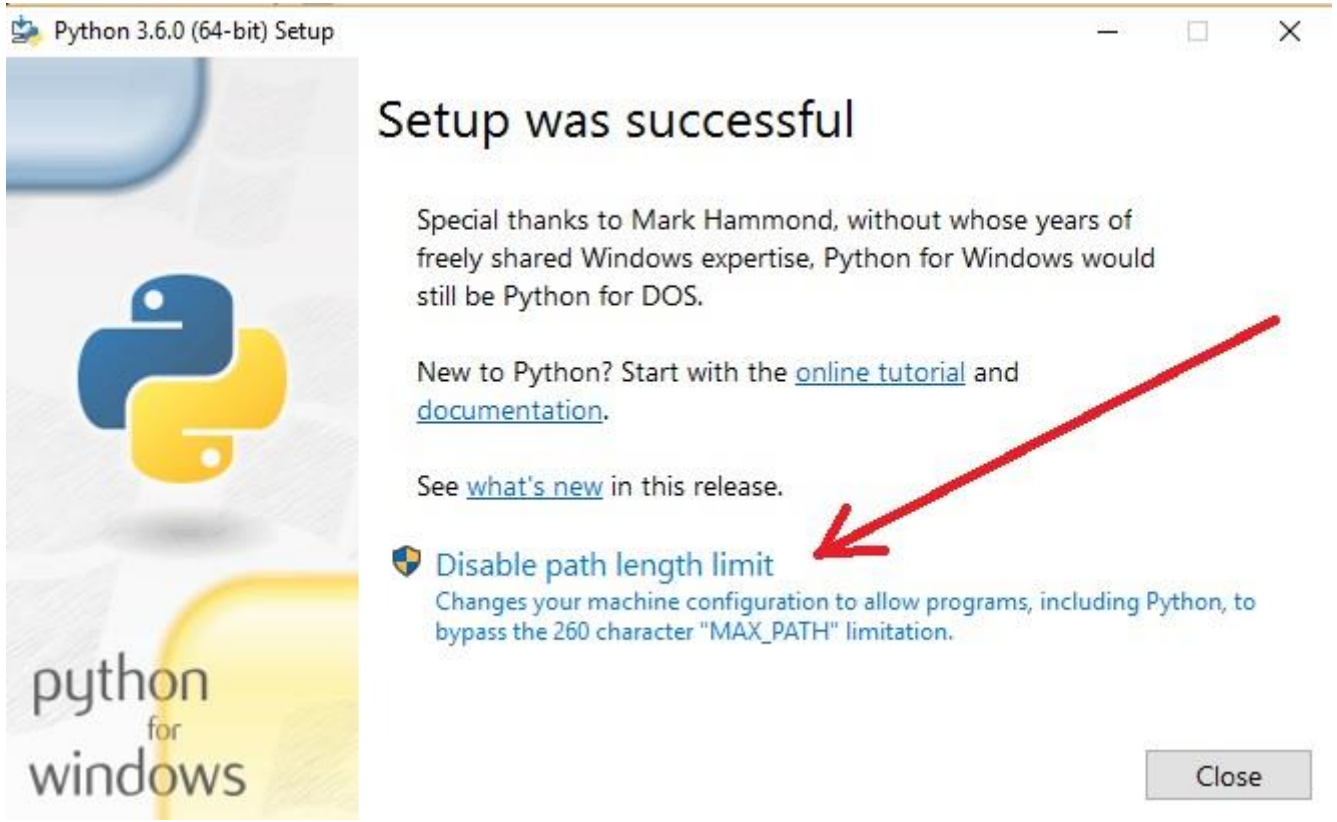
- https://www.python.org/downloads/



...Install Python



...Install Python



...Install Python

- Other options in Windows OS
  - Install Anaconda
    - Python interpreter + useful libraries and tools for data science
  - Use Windows Subsystem for Linux (WSL)
    - If you are working on Windows and want a Linux environment for working with Python

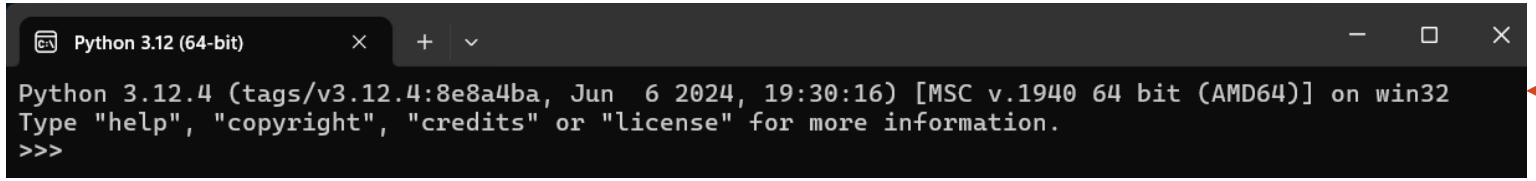
```
python3 --version
```

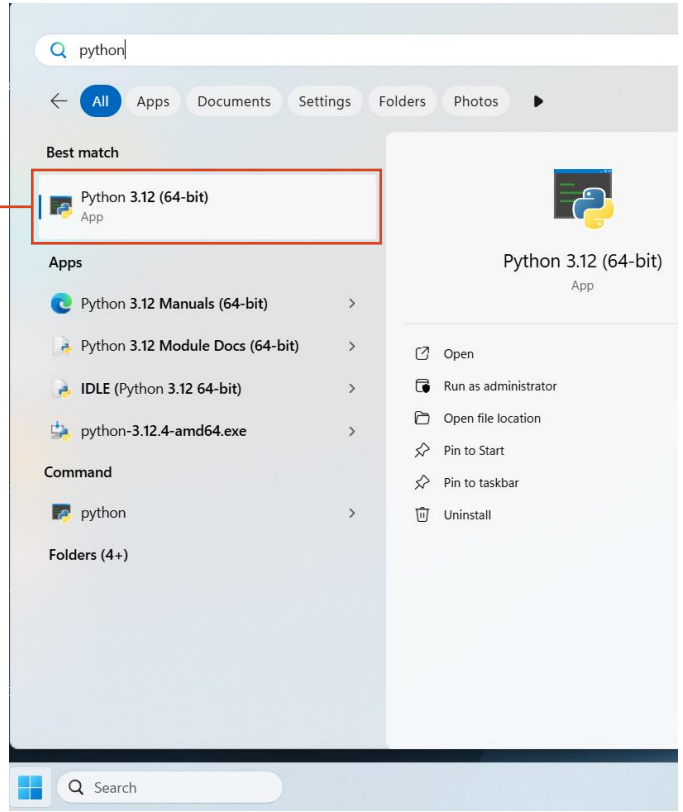
Test

Coding

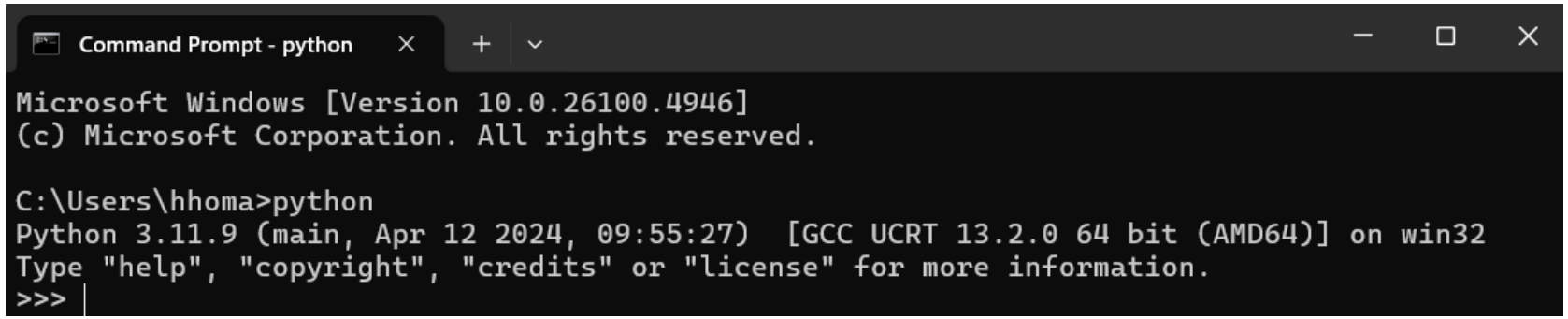
- You can start coding by the default Python REPL (Read-Eval-Print Loop)
  - Interactive programming environment
    - Write and execute code in a step-by-step manner and get immediate feedback

Run from Windows Strat Menu





Run from Command Prompt



...Coding

- Single line example

```
Python 3.12 (64-bit)
Python 3.12.4 (tags/v3.12.4:8e8a4ba, Jun  6 2024, 19:30:16) [MSC v.1940 64 bit (AMD64)] on win32
Type "help", "copyright", "credits" or "license" for more information.
>>> print("Hello world!")
Hello world!
>>>
```

- Multi-line examples

Difficult! Isn't it?

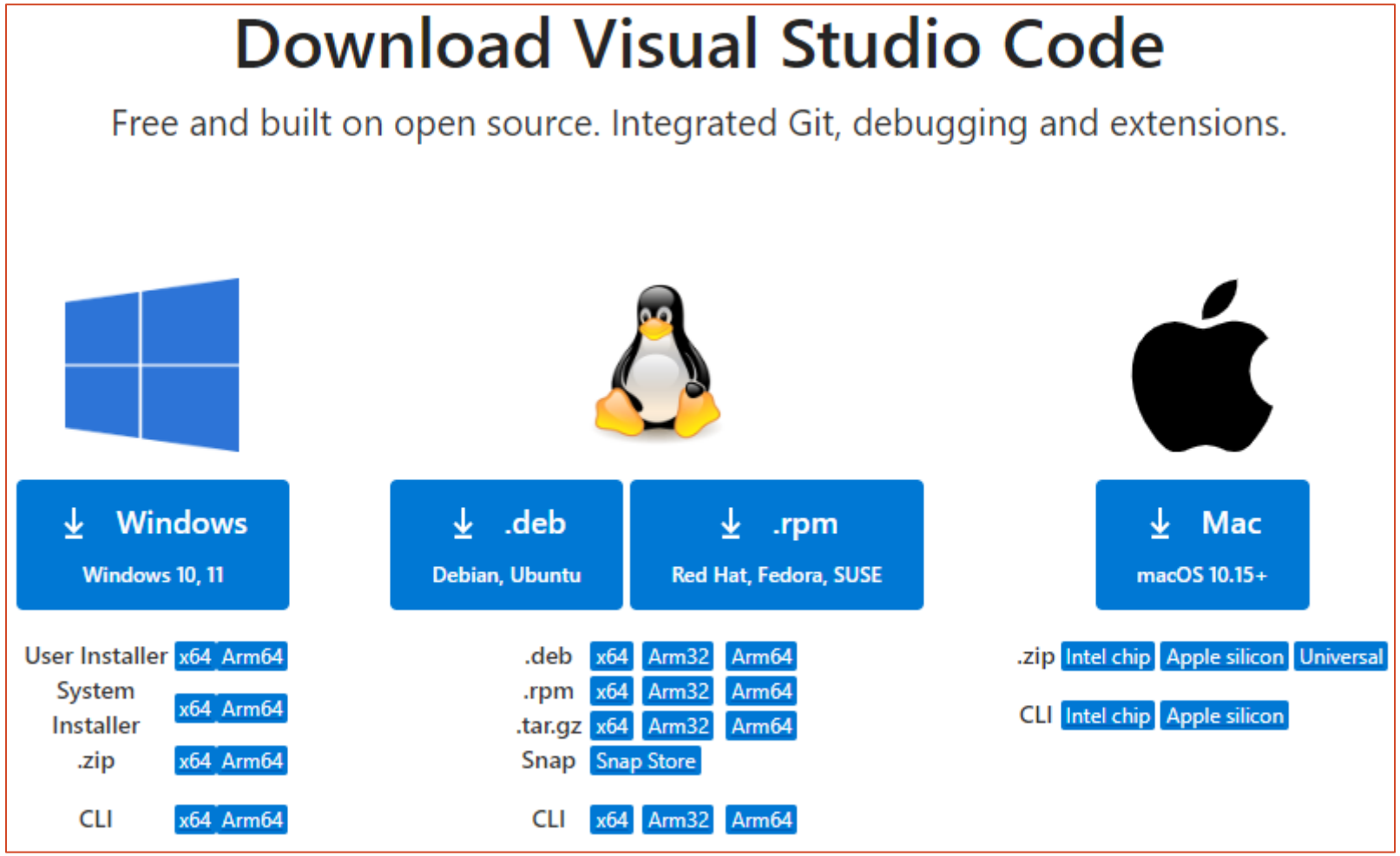
```
>>> print \
... ("My name is Hossein")
My name is Hossein
>>>
```

```
>>> x = "What is your name?"
>>> print(x)
What is your name?
>>>
```

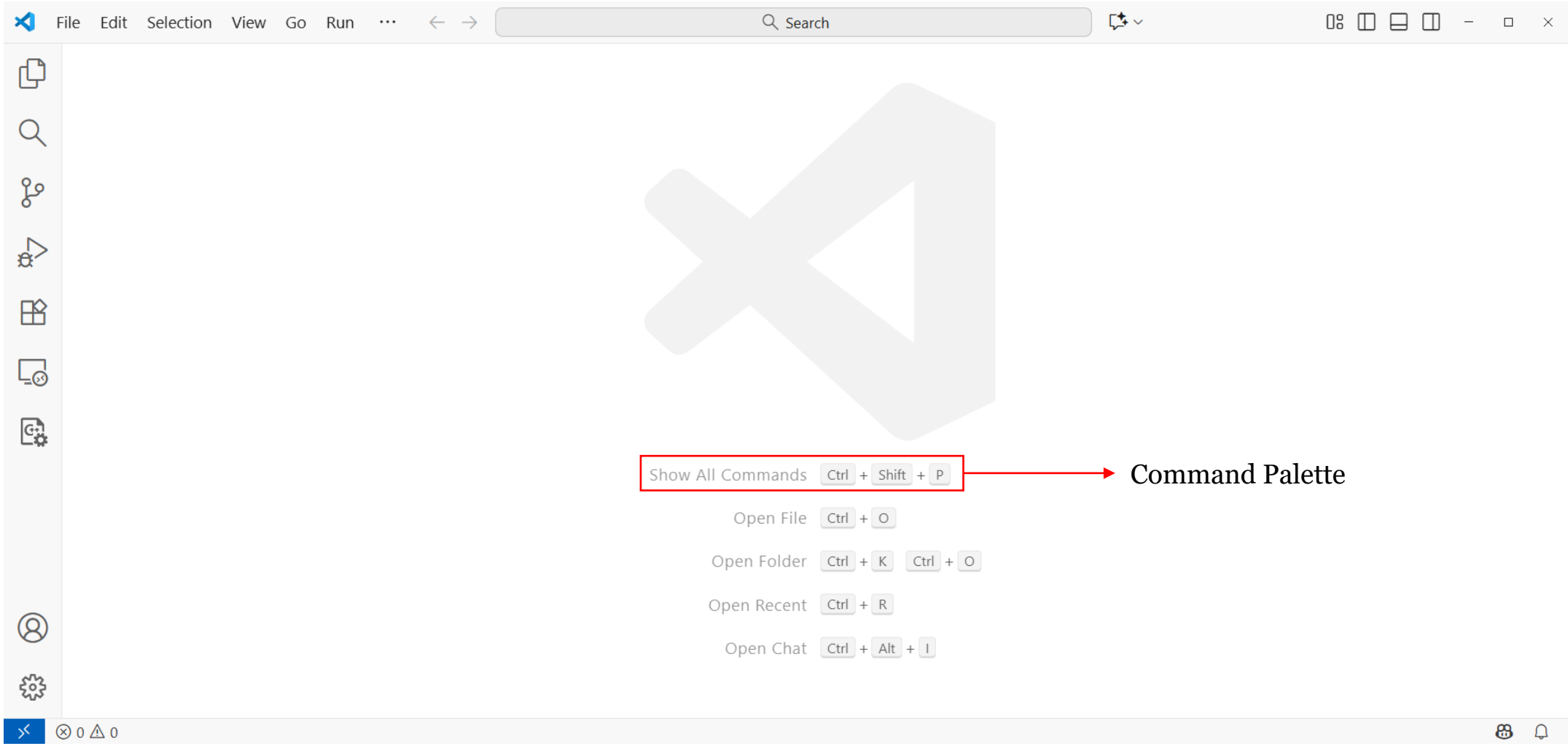
```
>>> print("Hello!"); print("How are you?")
Hello!
How are you?
```

```
>>> i = 1
>>> while i <= 5:
...     print(i)
...     i = i + 1
...
1
2
3
4
5
>>>
```

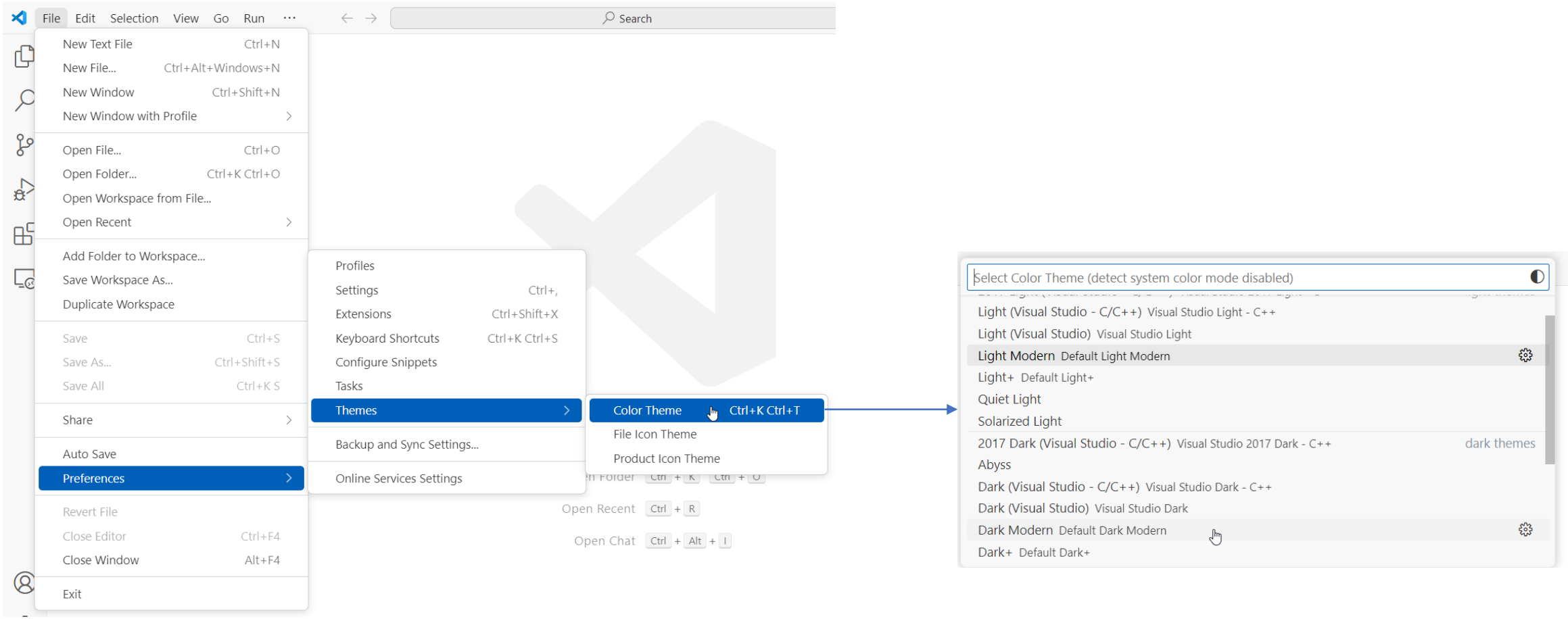
Install VS Code



VS Code Environment

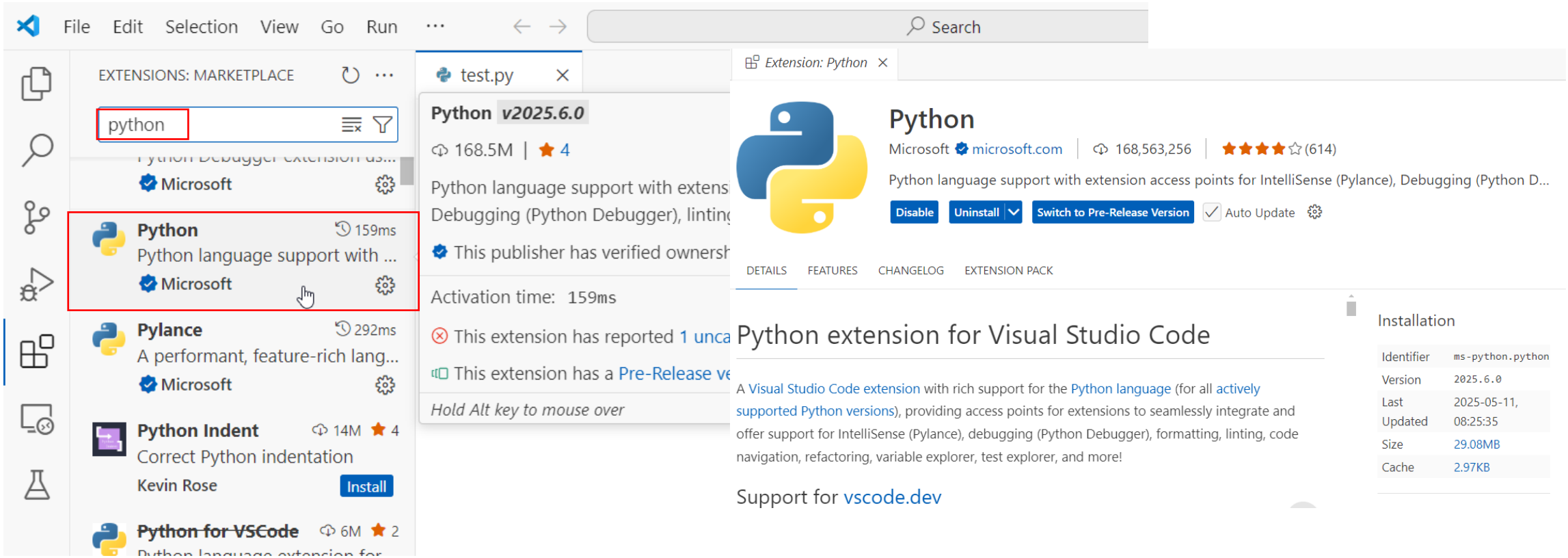


...VS Code Environment

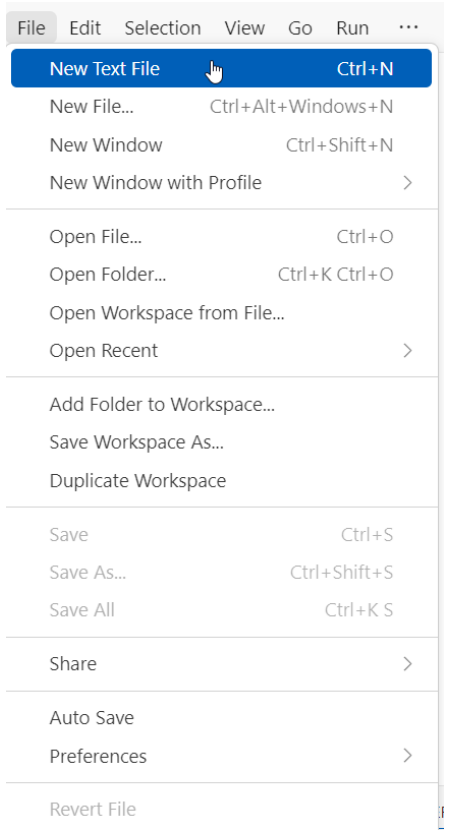


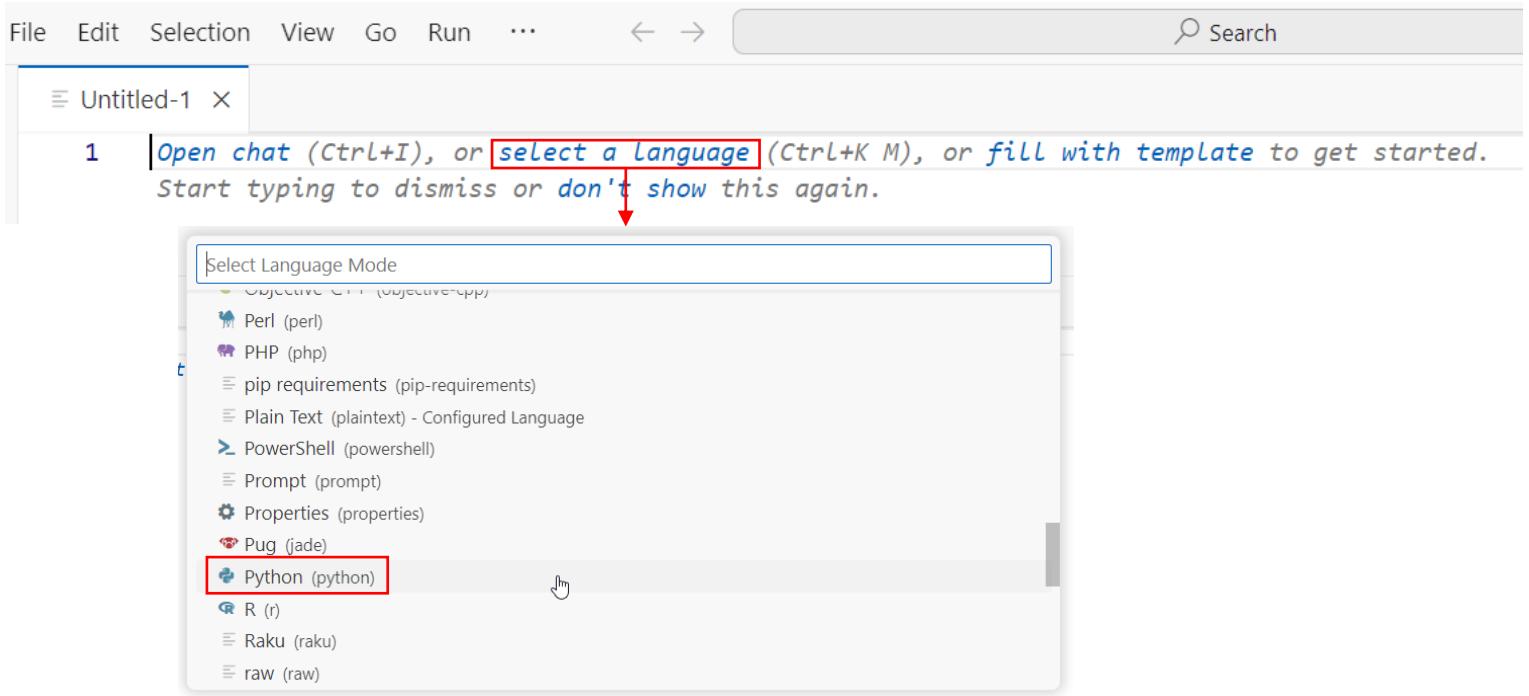
...VS Code Environment

- Install Python Extension on VS Code
  - Left side bar → Extensions → Search for Python

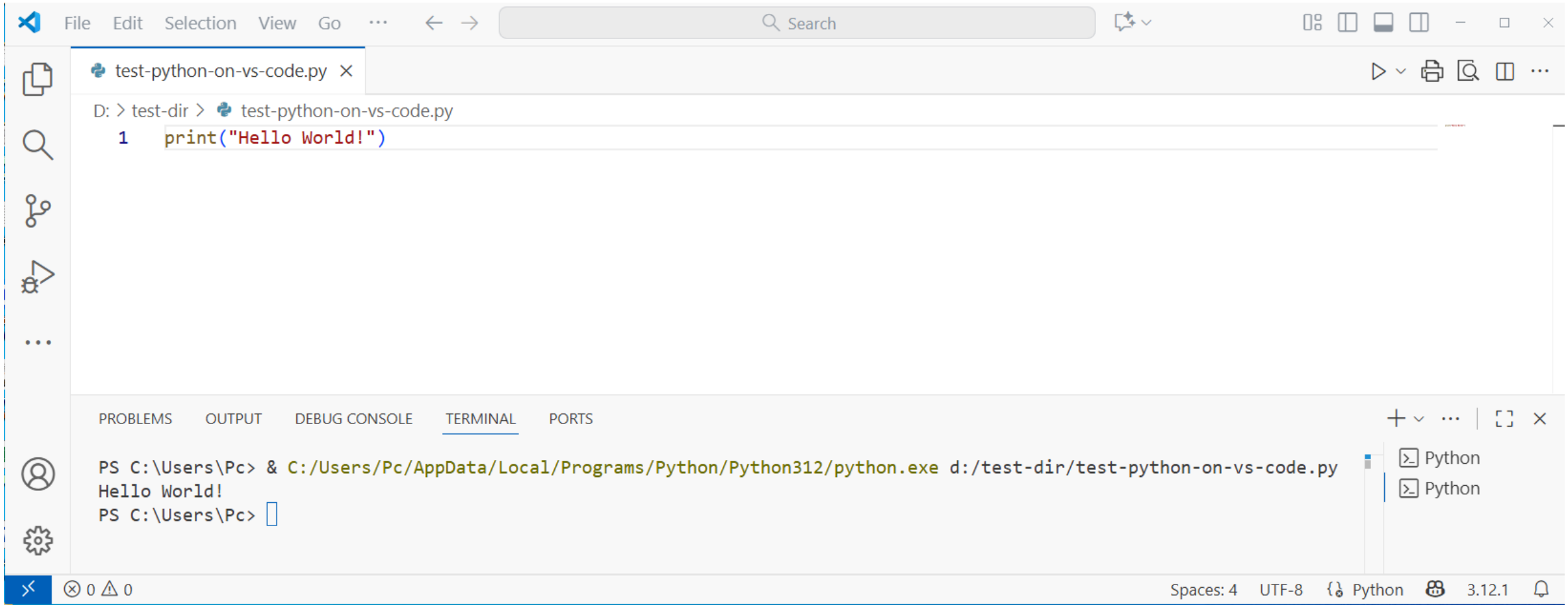


Testing Python on VS Code



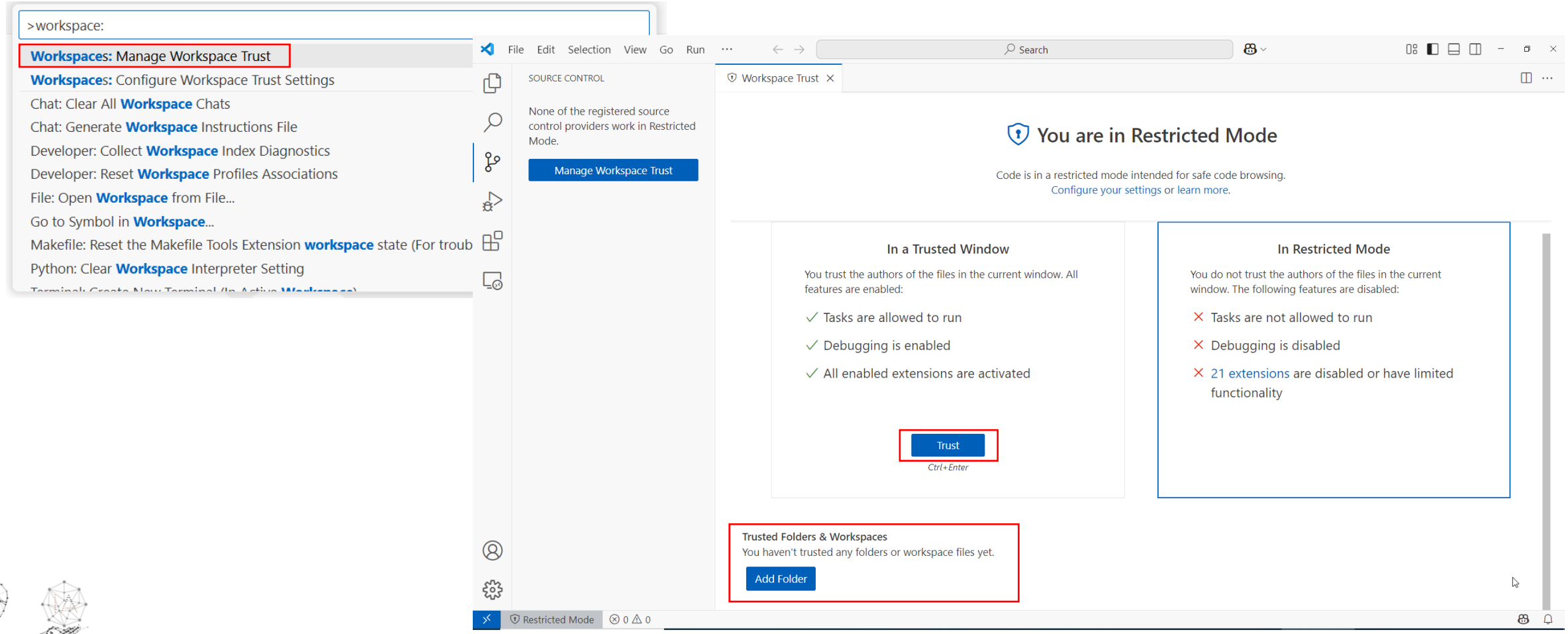


...Testing Python on VS Code



...Testing Python on VS Code

- It may require to be run from a trusted folder!



Main Python Libraries for Machine Learning

Array manipulation

Matrix manipulation

Series

Data-Frames

Drawing charts and plots

(Linear, Scatter and Pie plots, Bar Charts, Histograms, Boxplots, Heatmaps

Machine Learning Algorithms

Install the Required Libraries

- On the
  - Windows command prompt (cmd) or
  - command terminal of VS Code (ctrl+`)
- write `pip install` (or `python -m pip install`)
    - `numpy`
    - `pandas`
    - `scikit-learn`
    - `matplotlib`

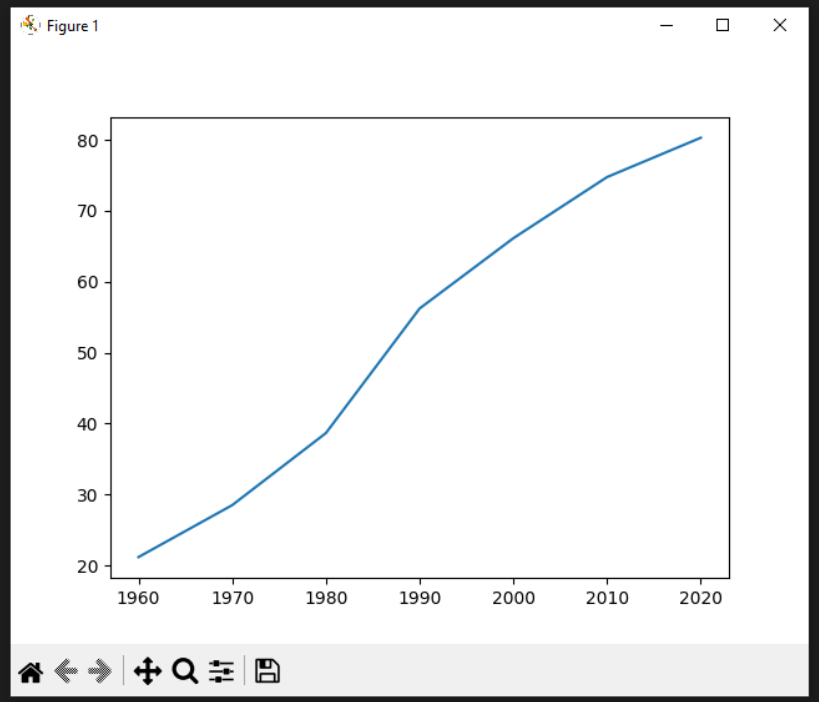
Troubleshooting

- NOTE-1: Sometimes previous versions work but the latest one does not.
  - Install an specific version:
    - `pip install “matplotlib=3.8.2”`

- NOTE-2: You may require GCC compiler on your system for working with Matplotlib
  - Follow the instruction explained by Microsoft: “C/C++ for Visual Studio Code”
    - Install MinGW-x64 on Windows: https://code.visualstudio.com/docs/languages/cpp

Test Libs

```python
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import sklearn.datasets as skdb

myArray = np.array([[1, 2, 3], [4, 5, 6], [7, 8, 9], [10, 11, 12]])
print ("myArray =\n", myArray, "\ndata type: ", myArray.dtype)

myDataFrame = pd.DataFrame(myArray,
                           index=['row1', 'row2', 'row3', 'row4'],
                           columns = ['col1', 'col2', 'col3'])
print("myDataFrame:")
print(myDataFrame)

iris=skdb.load_iris()
print("Iris dataset was loaded")

years = [1960, 1970, 1980, 1990, 2000, 2010, 2020]
iranpop = [21.19, 28.51, 38.67, 56.23, 66.13, 74.75, 80.29]

plt.plot(years, iranpop)
plt.show()
```



PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS Python

```
myDataFrame:
      col1  col2  col3
row1     1     2     3
row2     4     5     6
row3     7     8     9
row4    10    11    12
Iris dataset was loaded
```

Jupyter Notebook

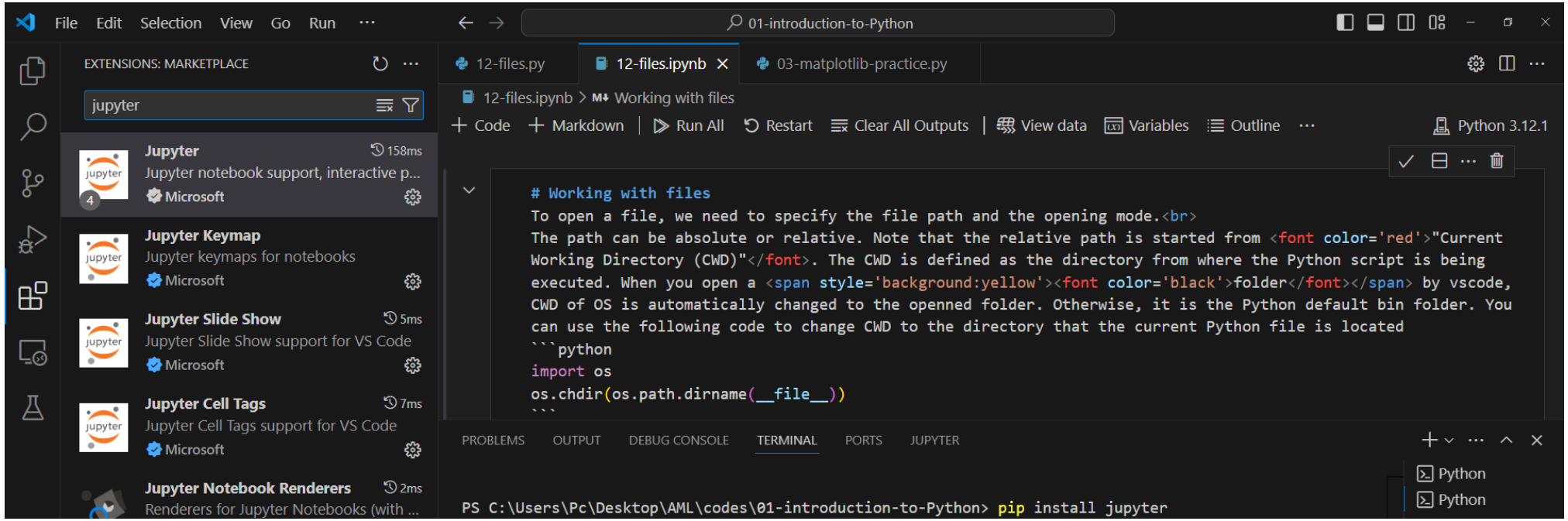
- Being familiar with Jupyter notebook is strongly recommended.
  - Why?
    - Many code examples of books and online courses at GitHub are written as Jupyter notebooks.

- What is it?
  - A powerful tool to create interactive documents containing text, images, and executable code snippets (Python in our case).
  - Jupyter's three core programming languages are Julia, Python and R.
  - Now, it supports various programming languages.

- Format of files = .ipynb
  - Why ipynb?
    - It was spun off from IPython project in 2014.

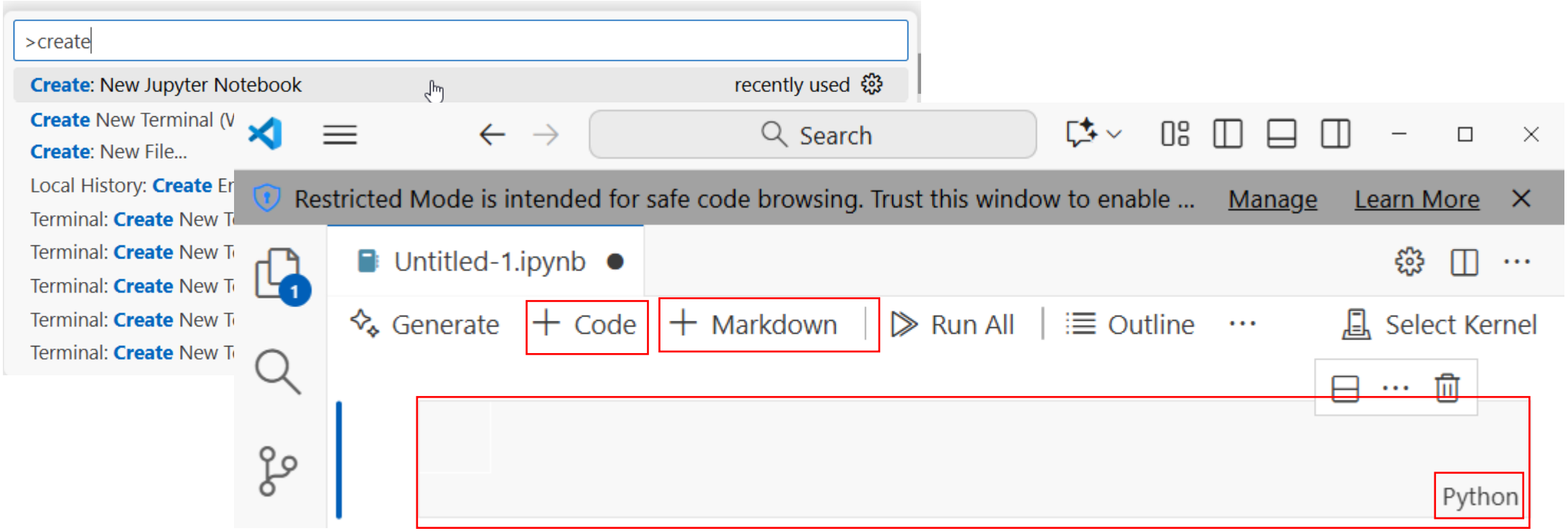
...Jupyter Notebook

- Install
  1. From the Command line: `pip install Jupyter`
  2. Install Jupyter Notebook extension on VS Code



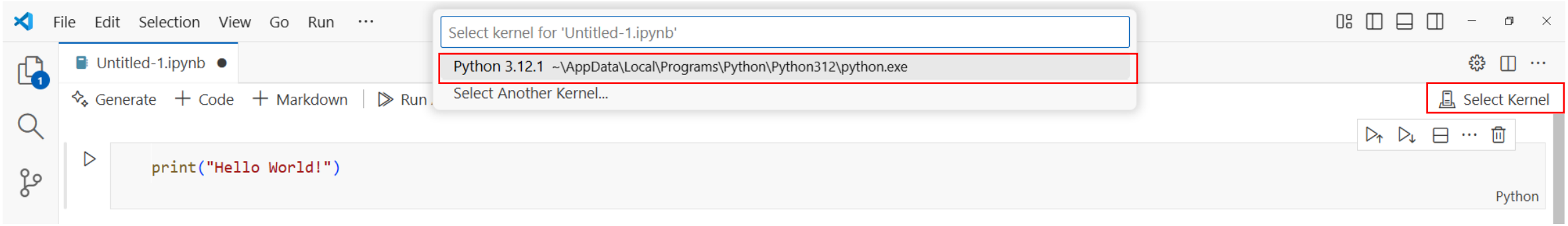
...Jupyter Notebook

- On VS Code

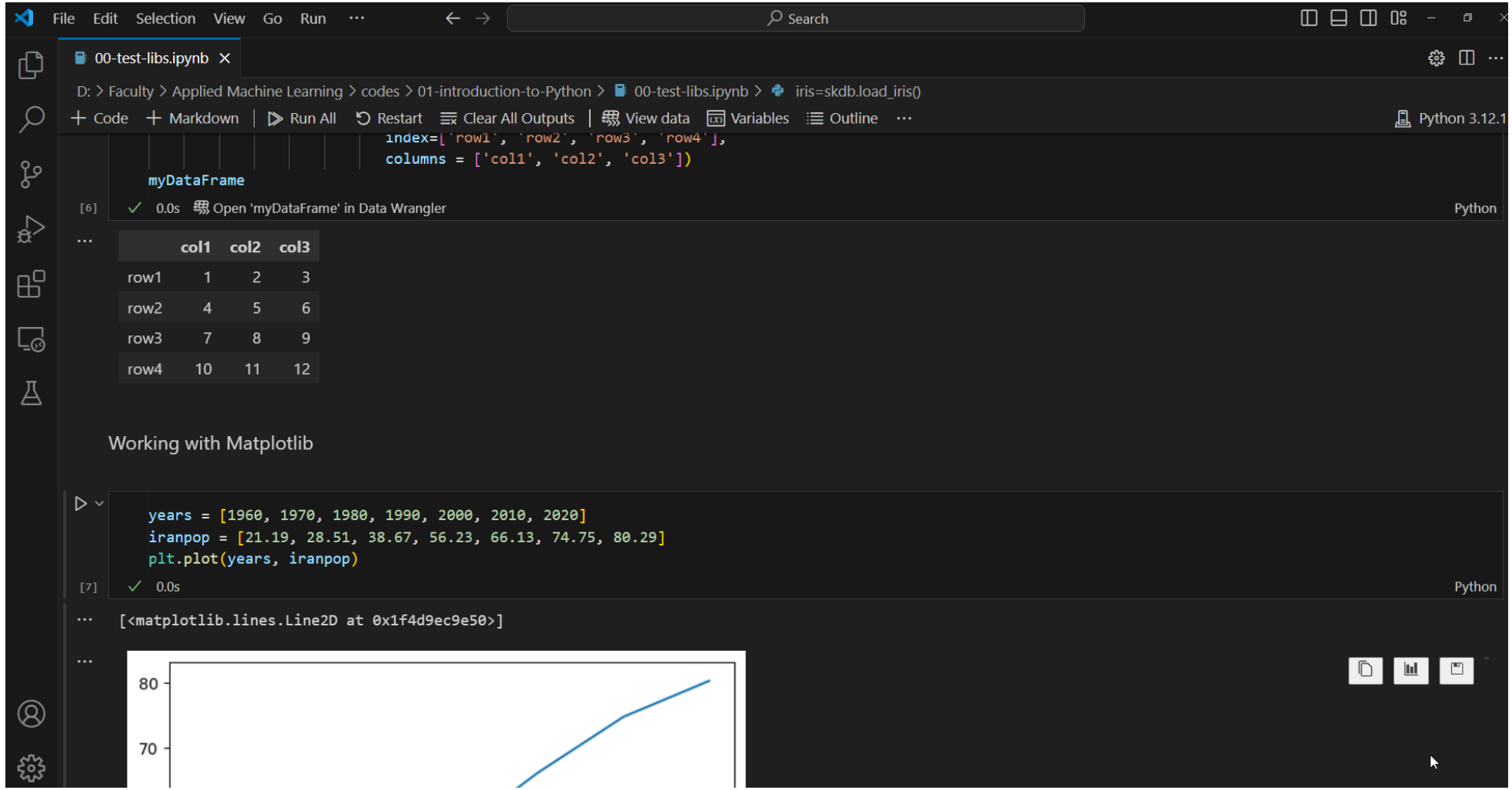


...Jupyter Notebook

- Example



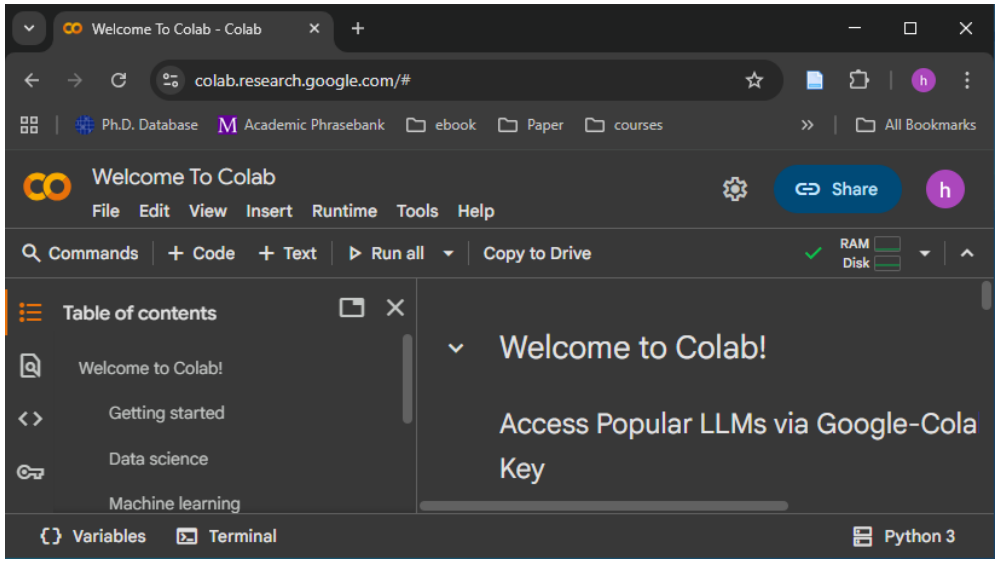
...Jupyter Notebook



...Jupyter Notebook

- Google Colab
  - Online Integrated Development Environment (IDE) for Python
  - No setup is required → Get rid of installation
  - Offers free access to computing resources, including GPUs and TPUs, making it popular among researchers and students working on deep learning and data science projects.
    - Access to GPUs is restricted and is NOT guaranteed
    - Notebooks can run for at most 12 hours

https://colab.research.google.com



Python Virtual Environment

- What is it?
  - A folder structure that gives you everything you need to run a lightweight yet isolated Python environment.
    - Created on top of an existing Python installation (base) and are isolated from the packages in the base environment.
  - When used from within a virtual environment, common installation tools such as pip, install Python packages into a virtual environment

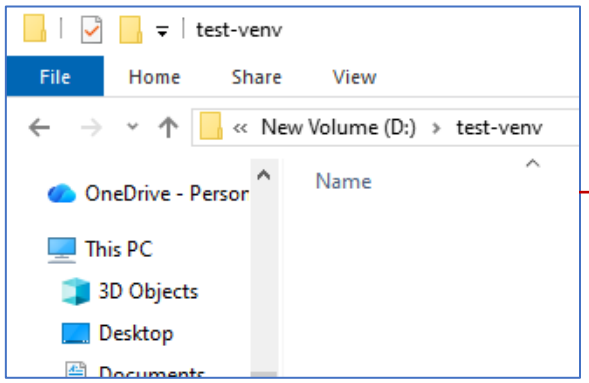
- Benefits
  - Manage dependencies separately for different projects
    - Minimize reproducibility issues
  - Preventing conflicts
  - Maintaining cleaner setups

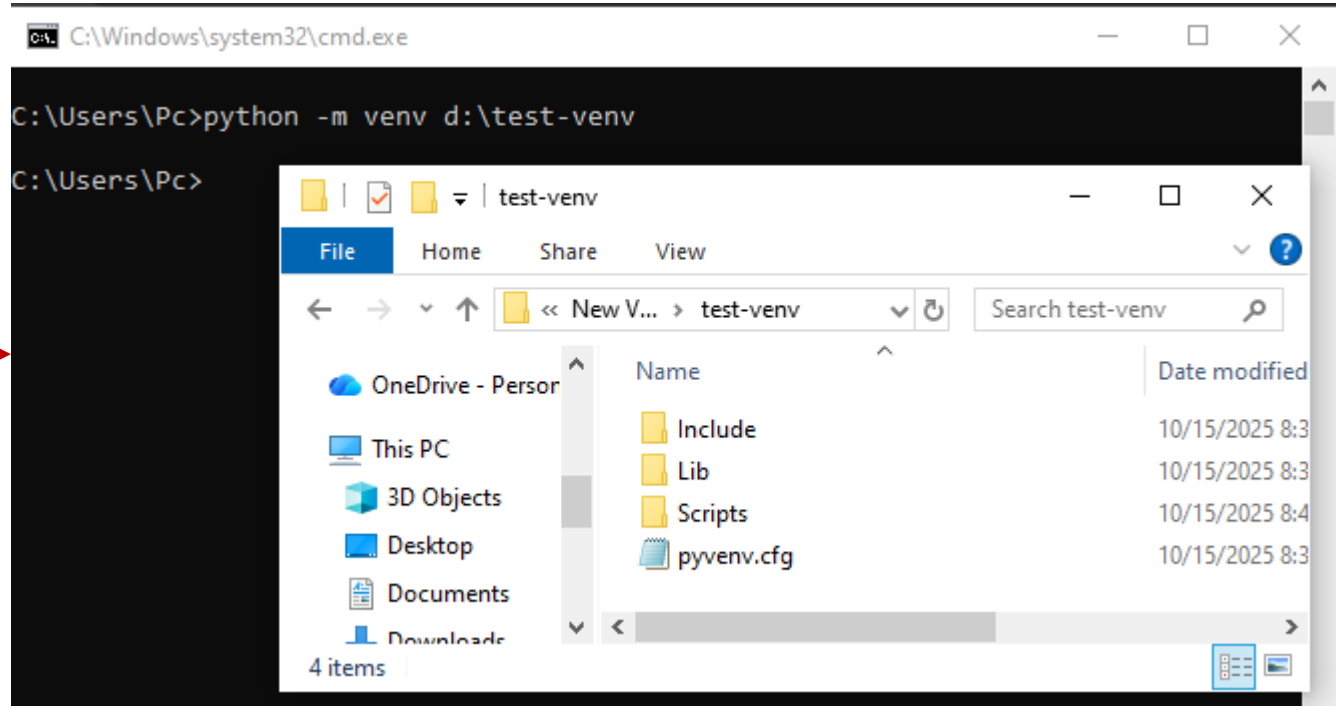
…Python Virtual Environment

- From the command line
  - `python –m venv ENV_DIR_PATH`
  - Note
    - If you have installed multiple Pythons on a single system and want to use a non-default version (not set to the PATH environmental variable as Python) as the base, use the entire path of the appropriate Python. Example:
      - `C:\Users\Name\AppData\Local\Programs\Python\Python312\python -m venv ENV_DIR_PATH`
- Activation
  - Go to the created virtual environment directory and run the activate script
    - `ENV_DIR_PATH\Scripts\Activate`

...Python Virtual Environment

- ...From the command line
  - Example





...Python Virtual Environment

- ...From the command line
  - ...Example

Activation

```
D:\test-venv>Scripts\activate

(test-venv) D:\test-venv>pip list
Package Version
------- -------
pip     23.2.1

[notice] A new release of pip is available: 23.2.1 -> 25.2
[notice] To update, run: python.exe -m pip install --upgrade pip
```

Install a package

```
(test-venv) D:\test-venv>python -m pip install rptree
Collecting rptree
  Obtaining dependency information for rptree from https://files.
  Downloading rptree-0.1.1-py3-none-any.whl.metadata (2.0 kB)
Downloading rptree-0.1.1-py3-none-any.whl (5.0 kB)
Installing collected packages: rptree
Successfully installed rptree-0.1.1

[notice] A new release of pip is available: 23.2.1 -> 25.2
[notice] To update, run: python.exe -m pip install --upgrade pip

(test-venv) D:\test-venv>pip list
Package Version
------- -------
pip     23.2.1
rptree  0.1.1

[notice] A new release of pip is available: 23.2.1 -> 25.2
[notice] To update, run: python.exe -m pip install --upgrade pip
```

Works on the venv

```
(test-venv) D:\test-venv>rptree d:\test-dir
d:\test-dir\
├── New folder\
│   ├── New Text Document 2.txt
│   └── New Text Document.txt
│
├── New folder 2\
│
└── New Text Document.txt
```

Deactivate

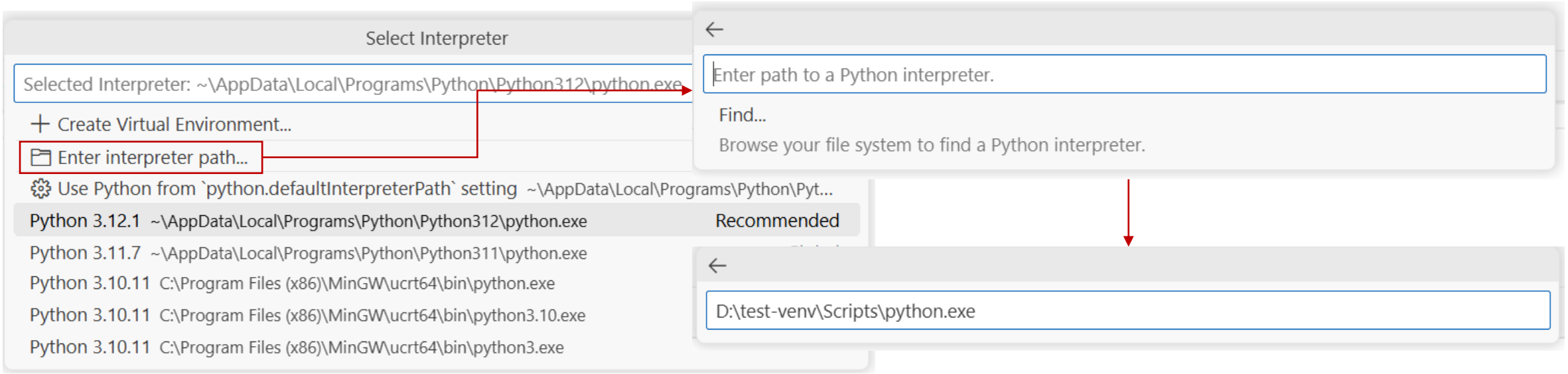
```
(test-venv) D:\test-venv>Scripts\deactivate
D:\test-venv>
```

Does not work on the venv

```
(test-venv) D:\test-venv>deactivate
D:\test-venv>rptree d:\test-dir
'rptree' is not recognized as an internal or external command,
operable program or batch file.
```

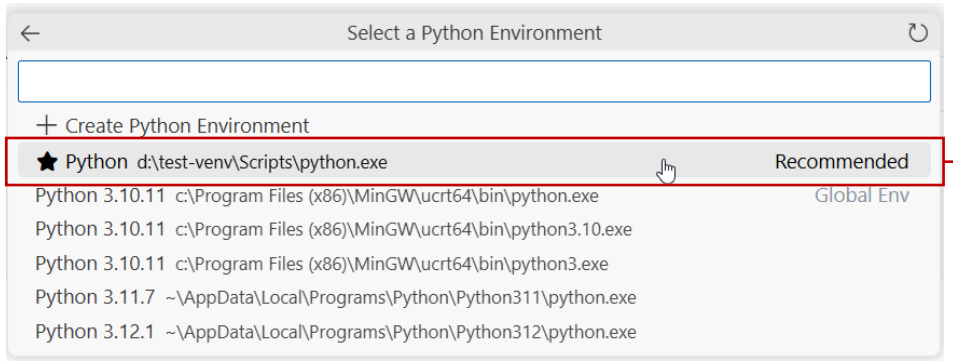
...Python Virtual Environment

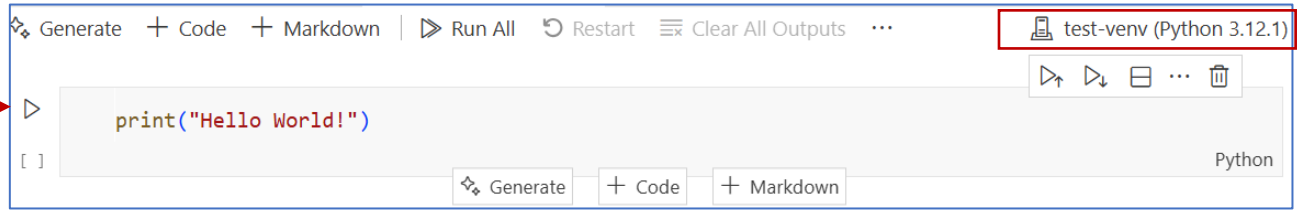
- From VS Code
  - Go to Command Palette and select `Python: Select Interpreter`
    - Enter previously created interpreter path or create a new one



...Python Virtual Environment

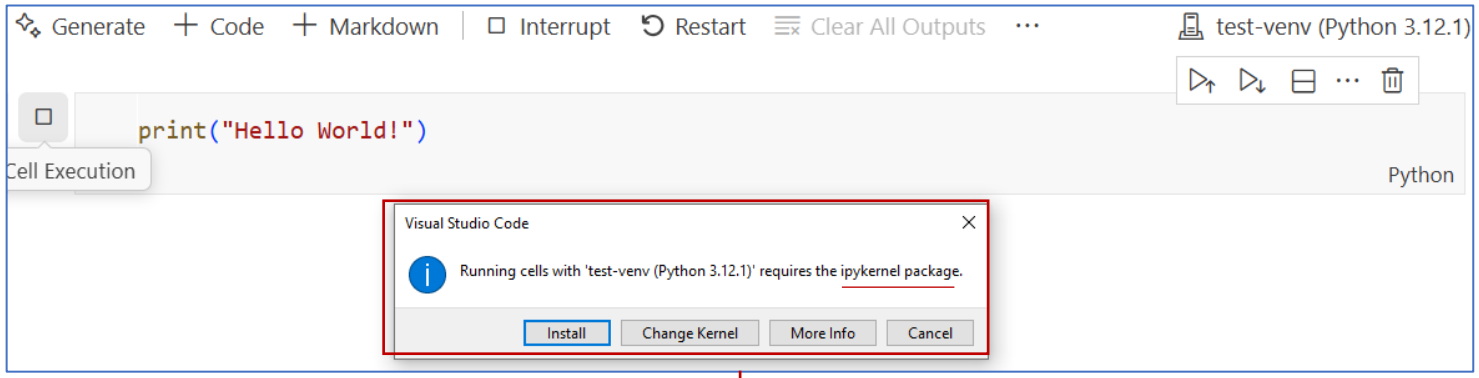
- ...From VS Code
  - On kernel selection step, select your virtual environment

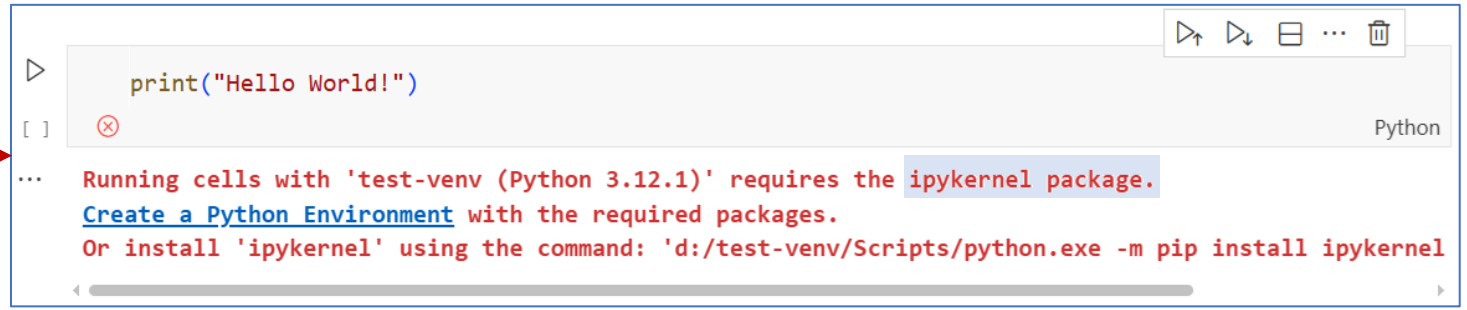




...Python Virtual Environment

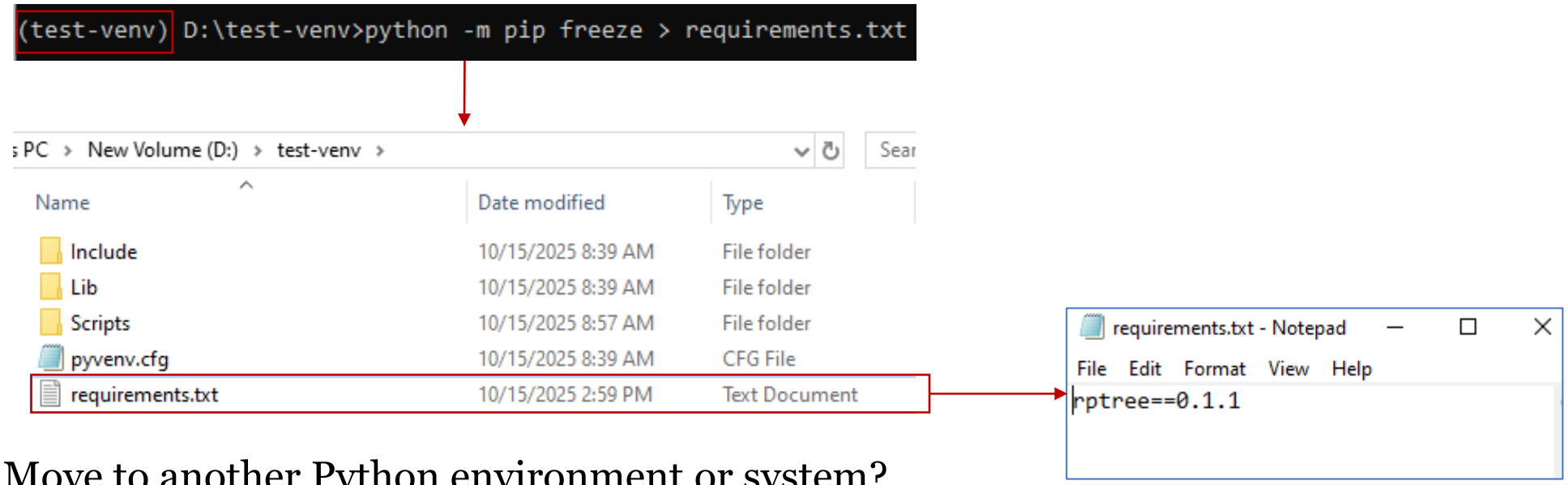
- ...From VS Code
  - Example





...Python Virtual Environment

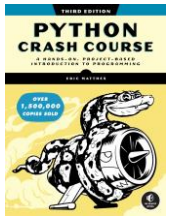
- Pin your dependencies
  - Make your virtual environment reproducible
  - Create requirements.txt which contains the list of installed packages
    - Use `pip freeze` command while your virtual environment is active



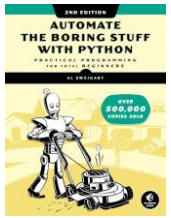
    - Move to another Python environment or system?
      - You have all the required packages names and versions Install them by a single simple command!
        - `python -m pip install -r requirements.txt`

How to Learn Python

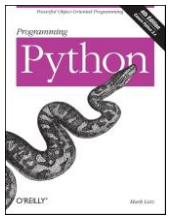
- Books



E. Matthes, Python crash course: A hands-on, project-based introduction to programming, 3rd ed. No Starch Press, 2023.



A. Sweigart, Automate the boring stuff with Python: practical programming for total beginners, 2nd ed. No Starch Press, 2019.



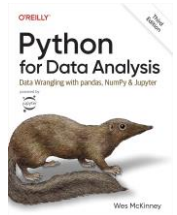
M. Lutz, Programming Python, 4th ed. O'Reilly Media, 2011.

+ Lots of online courses!

How to Learn Python Libraries

- Online user guides
  - https://numpy.org
  - https://pandas.pydata.org
  - https://matplotlib.org
  - https://scikit-learn.org

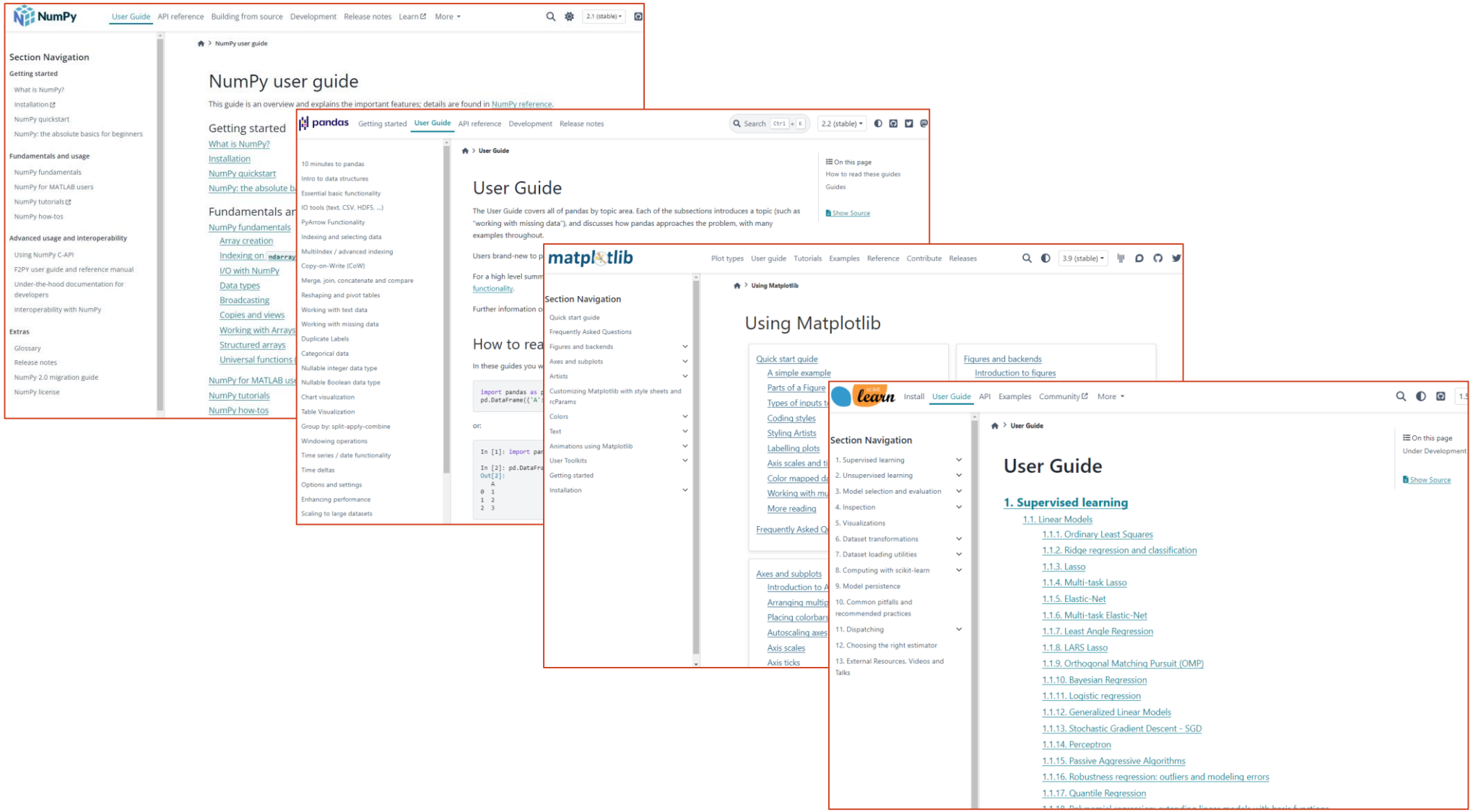
- W. McKinney, *Python for Data Analysis: Data Wrangling with pandas, NumPy, and Jupyter*, 3rd ed. O'Reilly Media, 2022.



- Online course
  - Applied Data Science with Python- Coursera Specialization,
    - Instructors: Christopher Brooks, Kevyn Collins-Thompson, Daniel Romero, and V. G. Vinod Vydiswaran
    - University of Michigan

+ Lots of online courses!

User guides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Working with missing data
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Categorical data
Nullable integer data type
Nullable Boolean data type
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Table Visualization
Group by: split-apply-combine
Windowing operations
Time series / date functionality
Time deltas
Options and settings
Enhancing performance
Scaling to large datasets
User Guide
The User Guide covers all of pandas by topic area. Each of the subsections introduces a topic (such as "working with missing data"), and discusses how pandas approaches the problem, with many examples throughout.
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1.1.10. Bayesian Regression
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Dictionaries
Modules
Classes
Files
Exceptions

All the codes are available online:
https://github.com/hhomaei/aml

let's start coding…