



MDMC

Master in Data Management
and Curation



Advanced Python Programming

Basic Software Development

Marco Prenassi

Laboratory of Data Engineering, Area Science Park

date





TABLE OF CONTENTS:

- Why?
- Basic software development concepts
- Basic approaches to development

SECONDARY GOALS:

- Work as a team
- 

WHY?

- Let's make a simple game

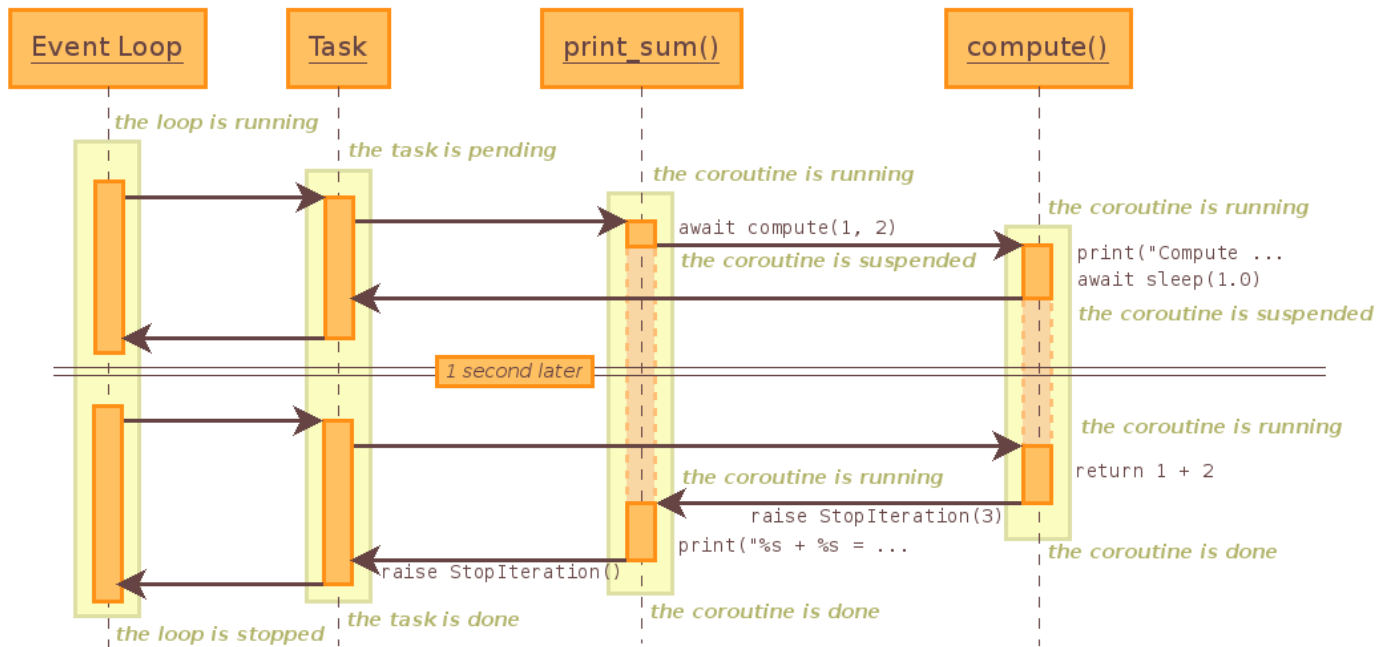
```
🕒 Time left: 46s
__=~+_,';-
=;'`^`#;:_
#~@*==*^`=
*.^~::~~#^+
^.:`.~::~~
~~;-~*-`_ =
W/A/S/D = move, I = inventory, Q = quit
-----
Inventory:
  1. Sword
  2. Shield
  3. Leather Armor
  4. Health Potion
  5. Torch
  6. Rope
(Press I again to close)
```

GITHUB:

git clone <https://github.com/Master-Data-Management-and-Curation/Advanced-Python-2025.git>

WHY?

- Managing Events (1/2)



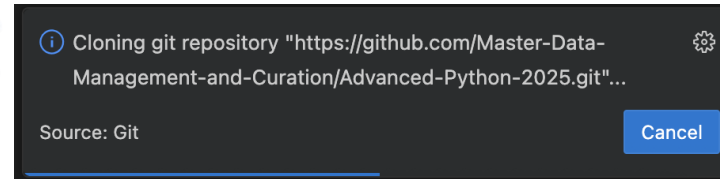
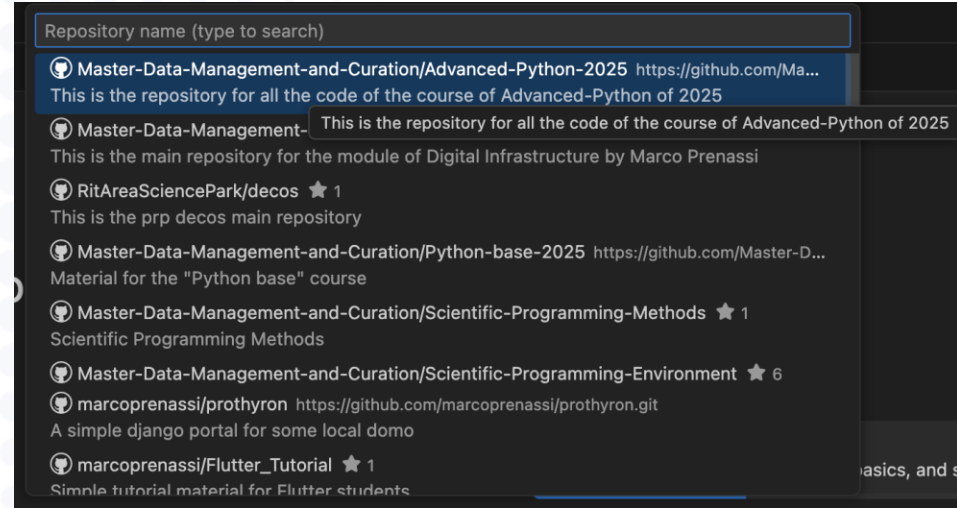
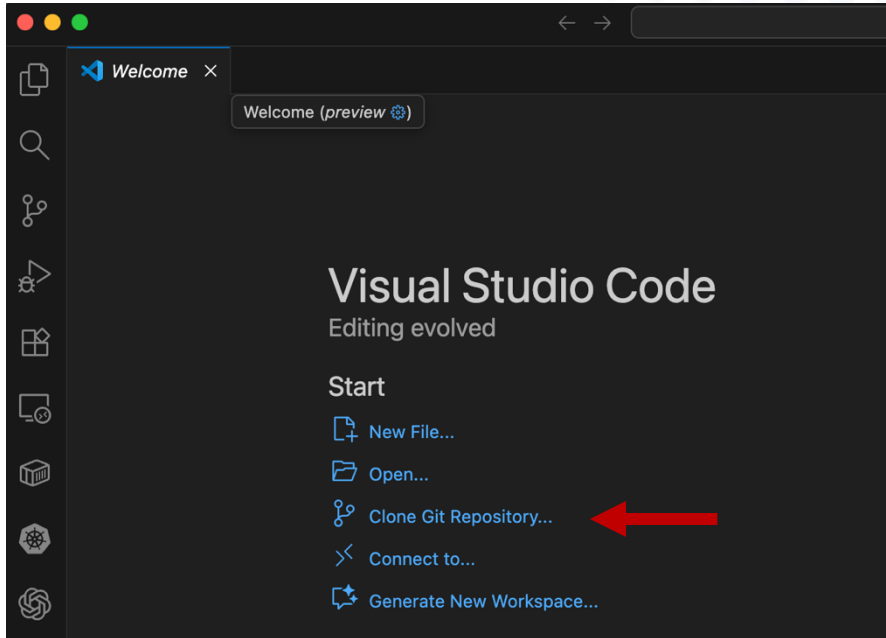
WHY?

- Managing Events

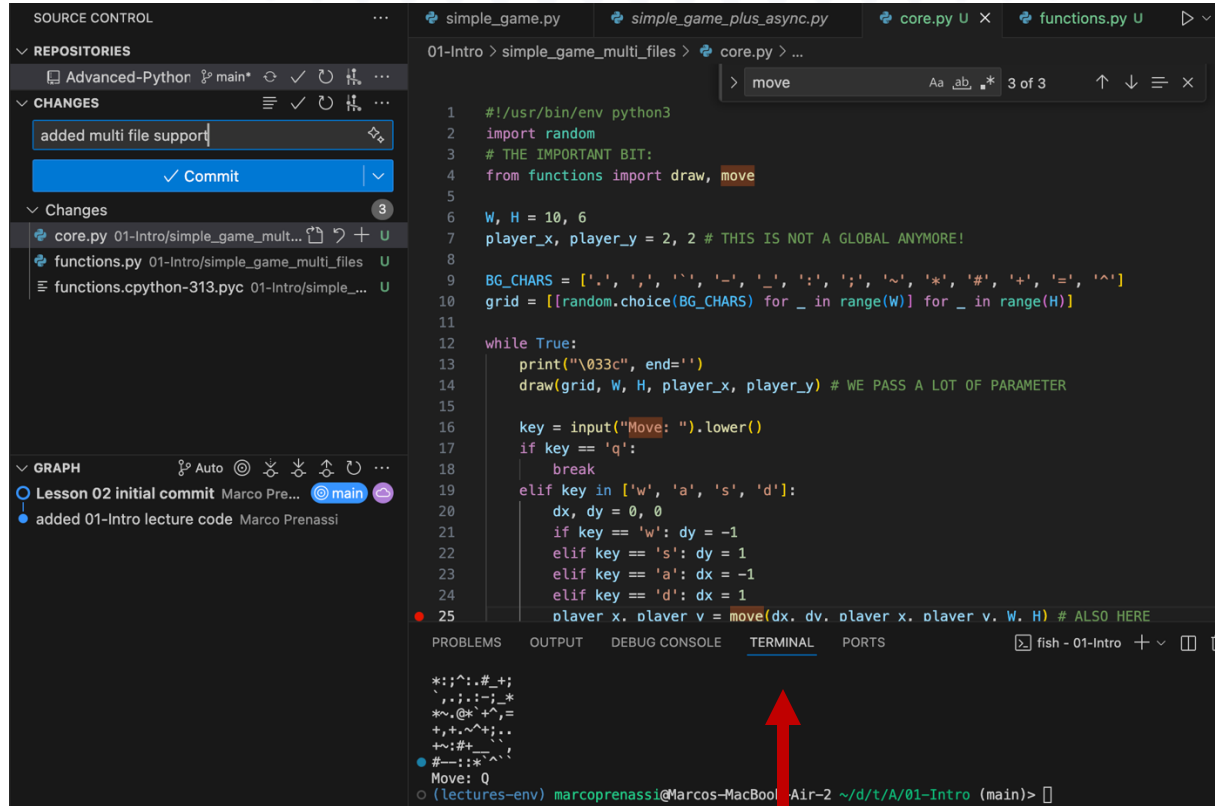


IDE: INTEGRATED DEVELOPMENT ENVIRONMENT

e.g., VISUAL STUDIO CODE



IDE: WHY



The screenshot displays the Visual Studio Code IDE interface. On the left, the 'SOURCE CONTROL' sidebar is open, showing a list of repositories and changes. The 'CHANGES' section highlights a commit titled 'added multi file support' with a blue 'Commit' button. Below this, the 'GRAPH' section shows a commit history with 'Lesson 02 initial commit' and 'added 01-Intro lecture code'. The main editor area shows a Python file named 'core.py' with the following code:

```
1 #!/usr/bin/env python3
2 import random
3 # THE IMPORTANT BIT:
4 from functions import draw, move
5
6 W, H = 10, 6
7 player_x, player_y = 2, 2 # THIS IS NOT A GLOBAL ANYMORE!
8
9 BG_CHARS = ['.', '-', '|', '^', '~', '!', '@', '#', '+', '=', '^']
10 grid = [[random.choice(BG_CHARS) for _ in range(W)] for _ in range(H)]
11
12 while True:
13     print("\033c", end='')
14     draw(grid, W, H, player_x, player_y) # WE PASS A LOT OF PARAMETER
15
16     key = input("Move: ").lower()
17     if key == 'q':
18         break
19     elif key in ['w', 'a', 's', 'd']:
20         dx, dy = 0, 0
21         if key == 'w': dy = -1
22         elif key == 's': dy = 1
23         elif key == 'a': dx = -1
24         elif key == 'd': dx = 1
25         player_x, player_y = move(dx, dy, player_x, player_y, W, H) # ALSO HERE
```

The bottom of the IDE shows the 'TERMINAL' tab, which contains the output of the program, including a grid of characters and the prompt 'Move: Q'. A red arrow points to the terminal output.

IDE: PYTHON and JUPYTER NOTEBOOKS

1. Create or activate the environment you want the kernel to use (in the folder of the repository)

```
python3 -m venv lecture-env
```

```
source ./lecture-env/bin/activate
```

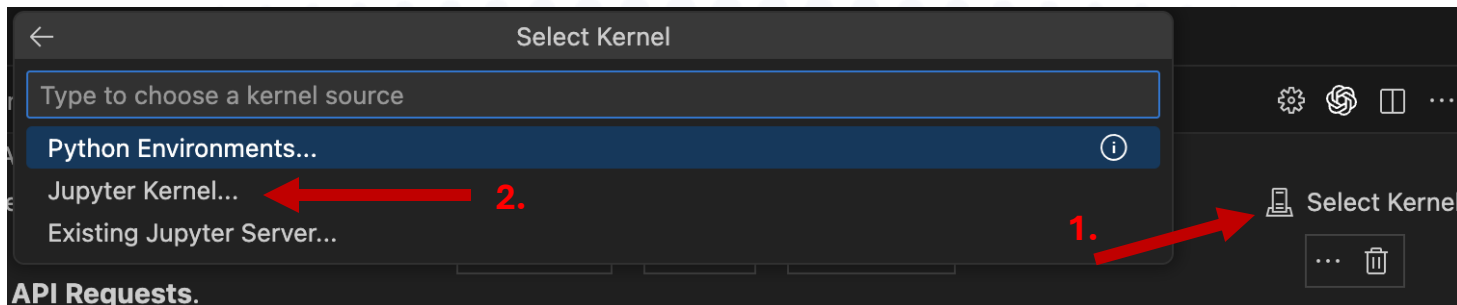
2. Install the kernel machinery in that env:

```
pip install ipykernel
```

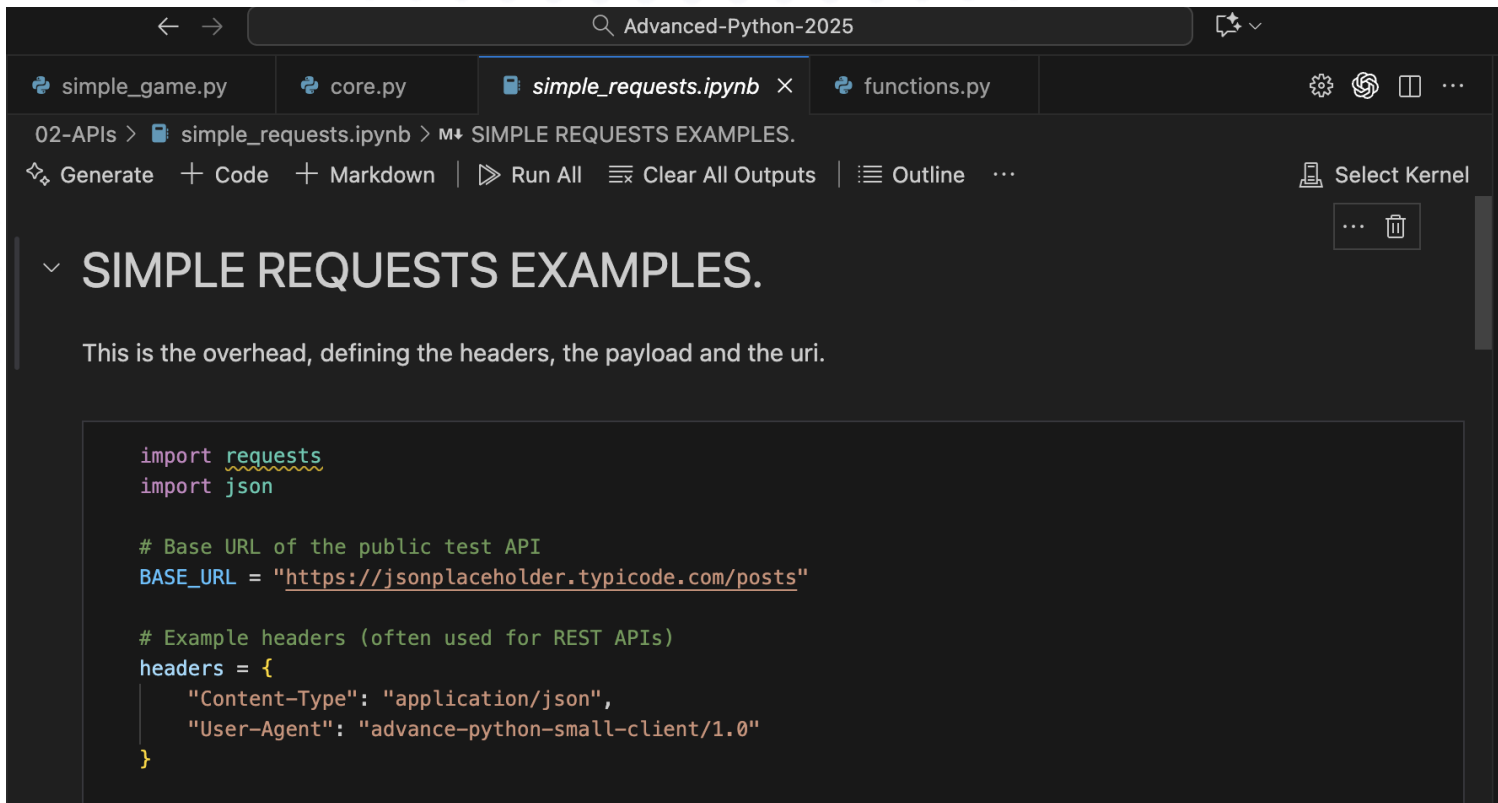
3. Register the kernel with Jupyter, giving it a recognizable name:

```
python -m lecture-env install --user --name advanced-python-kernel --display-name  
"Advanced Python Kernel"
```

4. Restart VSCODE, open a jupyter notebook and then select:



IDE: PYTHON and JUPYTER NOTEBOOKS



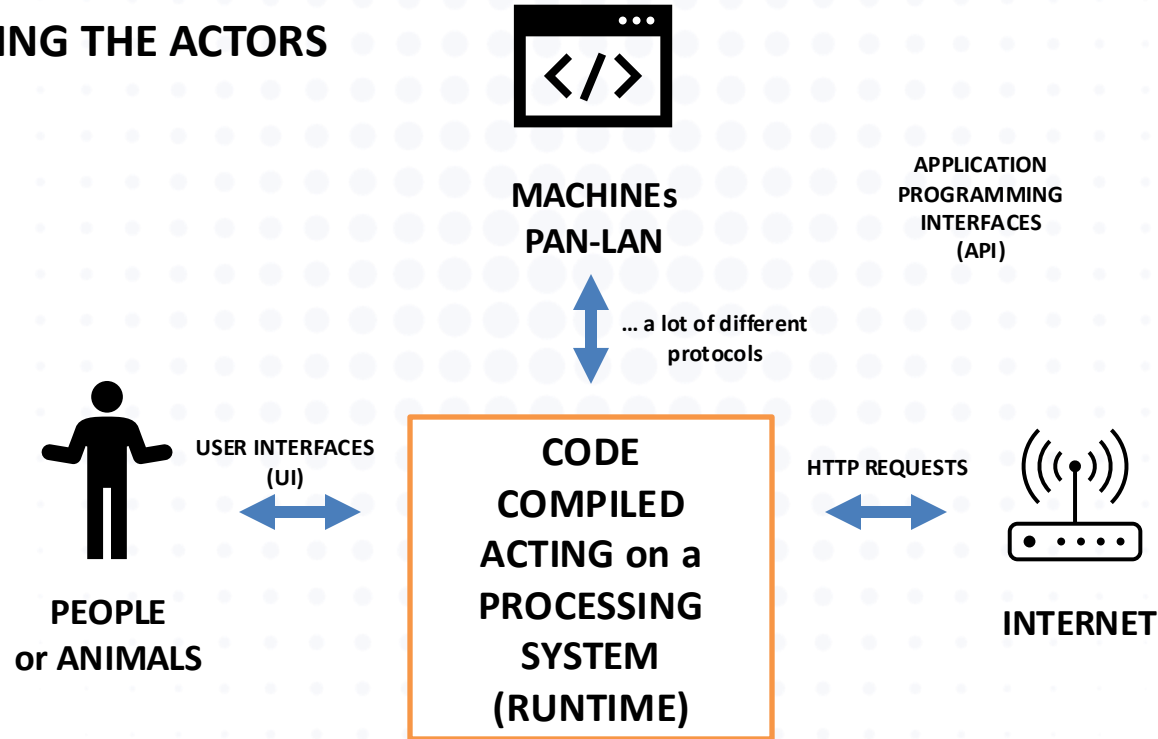
```
import requests
import json

# Base URL of the public test API
BASE_URL = "https://jsonplaceholder.typicode.com/posts"

# Example headers (often used for REST APIs)
headers = {
    "Content-Type": "application/json",
    "User-Agent": "advance-python-small-client/1.0"
}
```

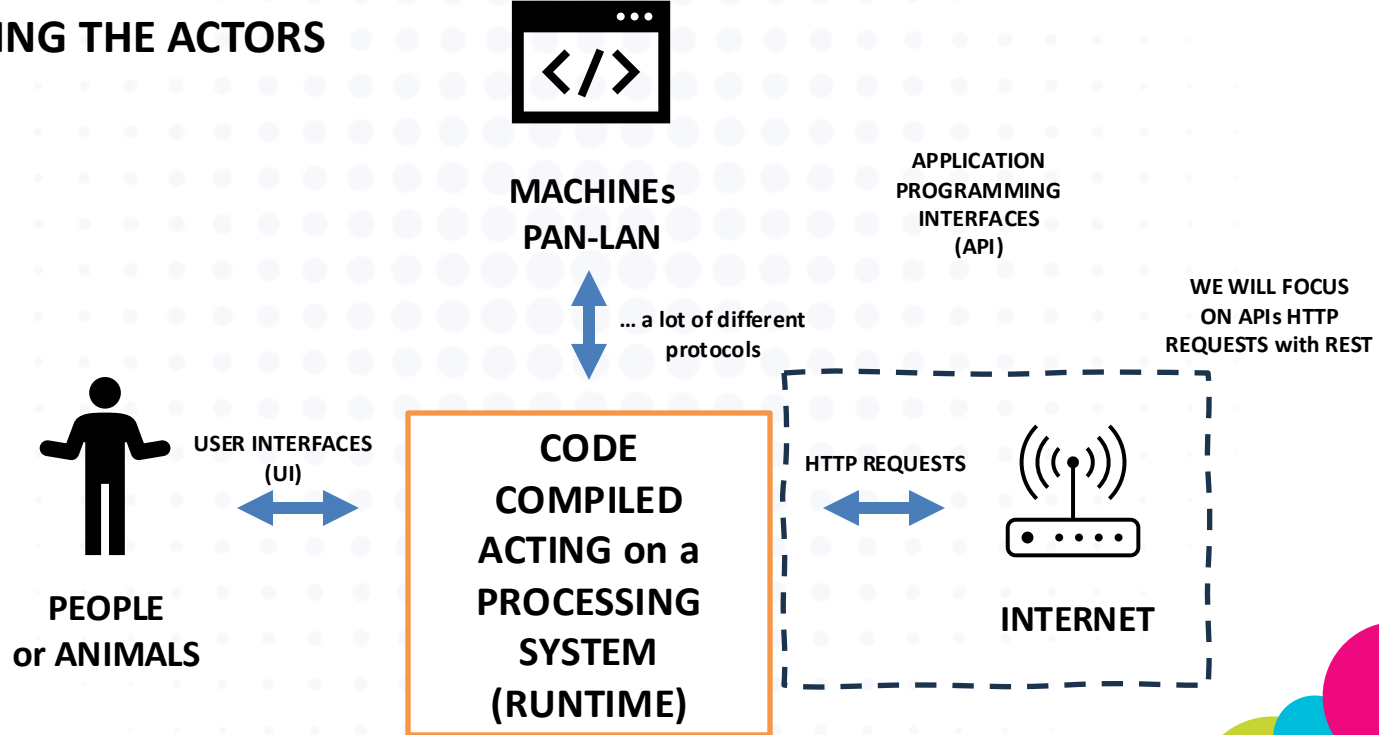
MANAGING EVENTS

INTRODUCING THE ACTORS



MANAGING EVENTS

INTRODUCING THE ACTORS



HTTP PROTOCOL BASIC CONCEPTS

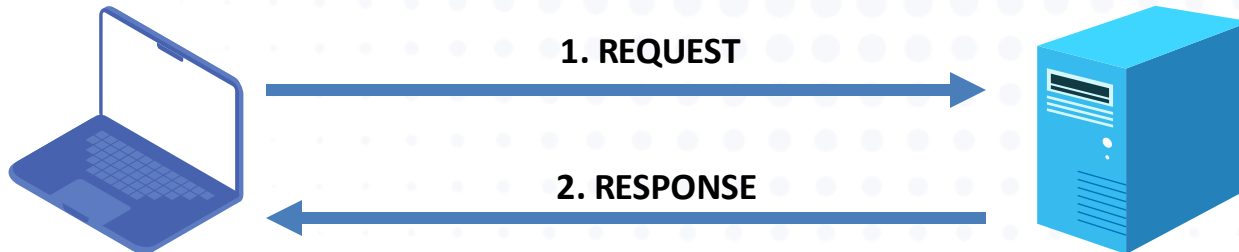
HTTP (HyperText Transfer Protocol) is **standard application-level protocol** used for exchanging **files on the World Wide Web**.

HTTP runs on top of the TCP/IP protocol and (later) on the QUIC protocol.

Web browsers are HTTP clients that send file requests to **Web servers**, which in turn handle the requests via an **HTTP service**.

STATELESS!!

EVERY REQUEST IS NOT DEFINED BY THE PREVIOUS ONE



HTTP REQUESTS

An HTTP request has **four main parts**:

1.Method (Type): what action to perform

2.URL (Endpoint): what resource to act on

3.Headers: extra info about the request (e.g., Authorization)

4.Body (Payload): data sent to the server (if needed, remember, these are REQUESTS)

e.g.,

1. POST /api/users HTTP/1.1
2. Host: api.example.com
3. Content-Type: application/json
4. { "name": "John", "role": "researcher" }

Request method	RFC	Request has payload body	Response has payload body
GET	RFC 9110	Optional	Yes
HEAD	RFC 9110	Optional	No
POST	RFC 9110	Yes	Yes
PUT	RFC 9110	Yes	Yes
DELETE	RFC 9110	Optional	Yes
CONNECT	RFC 9110	Optional	Yes
OPTIONS	RFC 9110	Optional	Yes
TRACE	RFC 9110	No	Yes
PATCH	RFC 5789	Yes	Yes

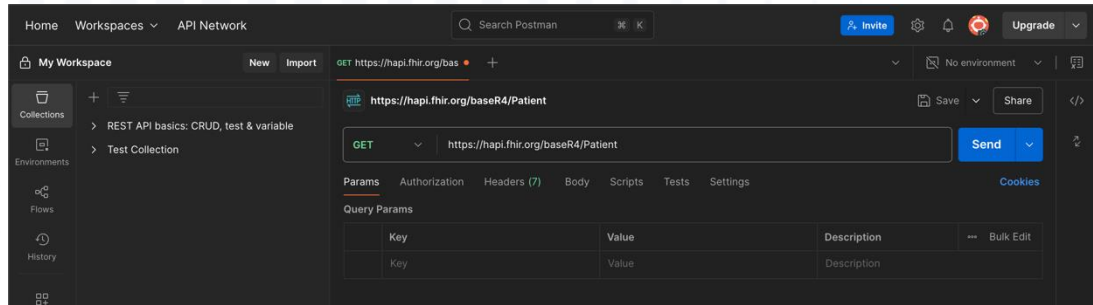
<https://en.wikipedia.org/wiki/HTTP>

HTTP REQUESTS – LET'S TRY

HOW:

1. CURL (UNIX or WINDOWS ALIAS)
2. REQUESTS MODULE IN PYTHON
3. POSTMAN
4. ... MANY MORE

POSTMAN (<https://web.postman.co/home>):



CURL:

Unix (macOs + Linux):

```
curl --method GET -H "Accept: application/fhir+json" https://hapi.fhir.org/baseR4/Patient/example
```

Windows powershell:

```
Invoke-RestMethod -Uri "https://hapi.fhir.org/baseR4/Patient/example" -Method GET  
-Headers @{ "Accept" = "application/fhir+json" } (In a single line!!!)
```


HTTP REQUESTS - SWAGGER

Swagger:

<https://hapi.fhir.org/baseR4/swagger-ui/>

Swagger allows you to describe the structure of your APIs so that machines can read them. The ability of APIs to describe their own structure is the root of all awesomeness in Swagger.

from https://swagger.io/docs/specification/v2_0/what-is-swagger/

GET	/Patient/{id}	read-instance: Read Patient instance	▼
PUT	/Patient/{id}	update-instance: Update an existing Patient instance, or create using a client-assigned ID	▼ 
DELETE	/Patient/{id}	instance-delete: Perform a logical delete on a resource instance	▼
PATCH	/Patient/{id}	instance-patch: Patch a resource instance of type Patient by ID	▼

HTTP REQUESTS – RESPONSE CODES

1xx	2xx STATUS CODES	3xx	4xx CLIENT ERRORS	5xx SERVER ERRORS
	200 Ok 201 Accepted ...		400 Bad Request 401 Unauthorized ... 403 Forbidden 404 Not Found ... 418 I'm a teapot ...	500 Internal Server Error ... 502 Bad Gateway 503 Service Unavailable ...

HTTP REQUESTS – RESPONSE CODES

LET'S TRY SOMETHING SIMPLE WITH: 02-APIs/simple_requests.ipynb

snippets of code:

Create custom headers:

```
headers = {  
    "Authorization": "Bearer your_api_token", "Content-Type": "application/json",  
    "User-Agent": "Python-Requests/Example"  
}
```

Data to send with the POST request:


```
post_data = { "key1": "value1", "key2": "value2" }
```

Perform the POST request :

```
try:  
    post_response = requests.post(post_url, json=post_data, headers=headers)  
    print(f"Status Code: {post_response.status_code}")  
    print(f"Response Body: {post_response.json()}")  
except requests.RequestException as e:  
    print(f"Error during POST request: {e}")
```

HTTP REQUESTS – LET’S TRY ON SOMETHING REAL

LET’S START WITH RCSB



226,414 Structures from the PDB
1,068,577 Computed Structure Models (CSM)

PDB-101 PDB EMDataResource NAKB wwPDB Foundation PDB-Dev


- Documentation
- General Help
- Search and Browse
- Exploring a 3D Structure
- 3D Viewers
- Grouping Structures
- Sequence Viewers
- Tools
- Programmatic Access
 - File Download Services
 - Web Services Overview
 - Batch Downloads with Shell Script

Programmatic Access

Web Service

The Application Programming Interface (API) are:

- **Data API** serves to retrieve
- **Search API** serves to find
- **ModelServer API** is a service
- **VolumeServer API** is a service
- **1D Coordinate Server API** from multiple resources
- **Alignment API** provides a



226,414 Structures from the PDB
1,068,577 Computed Structure Models (CSM)

3D Structures Enter search term(s), Entry ID(s), or sequence Include CSM

Advanced Search | Browse Annotations Help

PDB-101 PDB EMDataResource NAKB wwPDB Foundation PDB-Dev

Access Computed Structure Models (CSMs) of available model organisms Learn more

Welcome

- Deposit
- Search
- Visualize
- Analyze
- Download**
- Learn

RCSB Protein Data Bank (RCSB PDB) enables breakthroughs in science and education by providing access and tools for exploration, visualization, and analysis of:

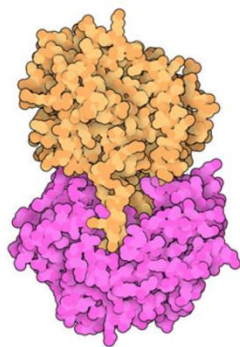
- Experimentally-determined 3D structures from the **Protein Data Bank (PDB)** archive
- **Computed Structure Models (CSM)** from AlphaFold DB and ModelArchive

These data can be explored in context of external annotations providing a structural view of biology.

Explore NEW Features

PDB-101 Training Resources

October Molecule of the Month



Angiotensin and Blood Pressure

Stay up-to-date with API developments by viewing (or subscribing) to the RCSB PDB API announcements Google group.

HTTP REQUESTS – LET’S TRY ON SOMETHING REAL

LET’S START WITH RCSB

and jupyter notebooks on

`02-APIs/RCSB_Mapping.ipynb`



RESTful

- **Uniform interface:** One piece of data belong to a single URI
- **Client-server decoupling:** You only need to know the URI of the server to interact
- **Statelessness:** all the information to process is included in the message, no previous operations required
- **Cacheability:** everything that is cacheable must be cached, to improve performance (client AND server side)
- **Layered system architecture:** the architecture is transparent to the layers inside
- **Code on demand*:** could give runnable code as a response (this is risky and must be done only on-demand).

SOAP vs REST

Simple Object Access Protocol (SOAP)! → POST ← GET, xml is an envelope

```
HTTP POST /ReturnValue HTTP/1.0 Host: www.abc.net Content-Type: text/xml; charset = utf-8 Content-Length: nnn
<?xml version = "1.0"?> <SOAP-ENV:Envelope xmlns:SOAP-ENV = "http://www.w3.org/2001/12/soap-envelope"
SOAP-ENV:encodingStyle = "http://www.w3.org/2001/12/soap-encoding">
<SOAP-ENV:Body xmlns:m = "http://www.abc.net/values"> <m:Value> <m:ValueName>Temperature</m:ValueName>
</m:GetValue> </SOAP-ENV:Body>
</SOAP-ENV:Envelope>
```

```
HTTP/1.0 200 OK Content-Type: text/xml; charset = utf-8 Content-Length: nnn
<?xml version = "1.0"?> <SOAP-ENV:Envelope xmlns:SOAP-ENV = "http://www.w3.org/2001/12/soap-envelope"
SOAP-ENV:encodingStyle = "http://www.w3.org/2001/12/soap-encoding">
<SOAP-ENV:Body xmlns:m = "http://www.abc.net/values"> <m: ValueResponse > <m: Value >25.0</m: Value>
</m: ValueResponse > </SOAP-ENV:Body>
</SOAP-ENV:Envelope>
```

How to "move fast": HTTP GET <http://www.abc.net?value=temperature> -> Response...

With **RESTful**: HTTP GET <http://www.abc.net/values/temperature> -> 25.0 (in JSON: {"temperature": 25.0})
also: let's use all the commands available in HTTP

WHY?

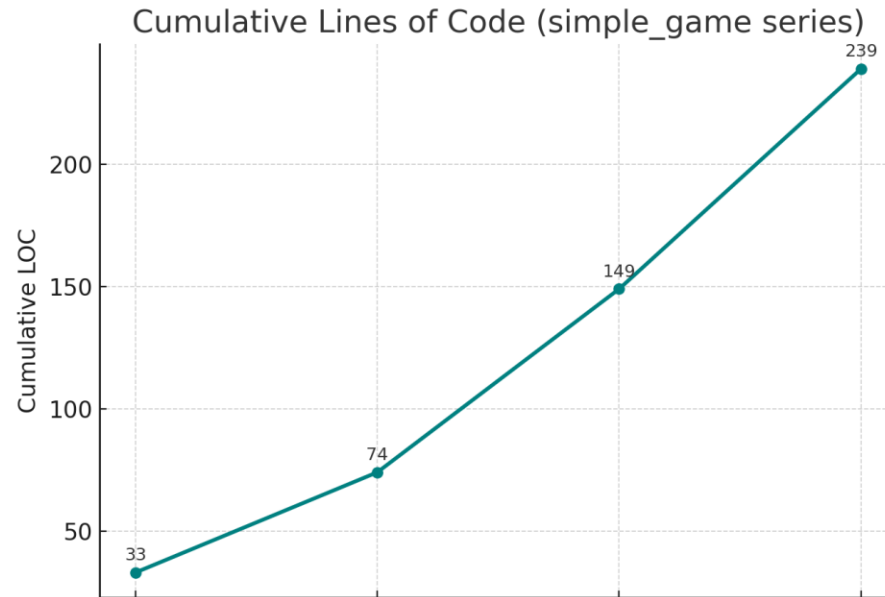
- Let's make a simple game

GITHUB:
git clone ...

```
⌚ Time left: 46s
__=~+_,`;-
=;`^`#;:_
#~@*==*^`=
*.^~:=~#^+
^.:`.~::~~~
~~;-~*-`_=_
W/A/S/D = move, I = inventory, Q = quit
-----
Inventory:
1. Sword
2. Shield
3. Leather Armor
4. Health Potion
5. Torch
6. Rope
(Press I again to close)
```

WHY?

- Lines Of Codes (LOC) growth by feature:



WHY?

- Managing complexity (2/2)

1.Object-Oriented Programming (OOP)

Organizes code around objects that combine data and behaviour; promotes encapsulation and reuse.

2.Functional Programming (FP)

Builds programs from pure, stateless functions and immutable data.

3.Data-Oriented Design (DOD)

Focuses on data layout and usage patterns for clarity and performance.

4.Entity-Component-System (ECS)

Composes entities from independent data components and processing systems.

5.Procedural / Modular Programming

Structures programs as reusable functions grouped into modules.

6.Declarative Programming

Describes *what* to do, leaving the *how* to the underlying system.

7.Actor Model

Uses independent actors that communicate via messages to handle concurrency safely.

8.Reactive Programming

Represents logic as data streams that automatically propagate changes.

9.Aspect-Oriented Programming (AOP)

Isolates cross-cutting concerns like logging or security into separate aspects.

10.Agent-Based Systems

Models systems as interacting autonomous agents with their own goals.

11.Dataflow Programming

Defines computation as a directed graph of data dependencies and transformations.

THESE ARE NOT ENEMIES
MULTI-PARADIGM
IS THE NORM

WHY?

- Managing complexity



1.Object-Oriented Programming (OOP)

Organizes code around objects that combine data and behaviour; promotes encapsulation and reuse.

2.Functional Programming (FP)

Builds programs from pure, stateless functions and immutable data.

3.Data-Oriented Design (DOD)

Focuses on data layout and usage patterns for clarity and performance.

4.Entity-Component-System (ECS)

Composes entities from independent data components and processing systems.

5.Procedural / Modular Programming

Structures programs as reusable functions grouped into modules.

6.Declarative Programming

Describes *what* to do, leaving the *how* to the underlying system.

7.Actor Model

Uses independent actors that communicate via messages to handle concurrency safely.

8.Reactive Programming

Represents logic as data streams that automatically propagate changes.

9.Aspect-Oriented Programming (AOP)

Isolates cross-cutting concerns like logging or security into separate aspects.

10.Agent-Based Systems

Models systems as interacting autonomous agents with their own goals.

11.Dataflow Programming

Defines computation as a directed graph of data dependencies and transformations.

THESE ARE NOT ENEMIES
MULTI-PARADIGM
IS THE NORM

“OPERATOR OVERLOAD” in PYTHON

Dunder Methods

special “magic” functions like `__init__`, `__str__`, `__add__` — they define how objects behave with Python’s built-in syntax. called automatically at runtime, never by the compiler.

Operator Overloading

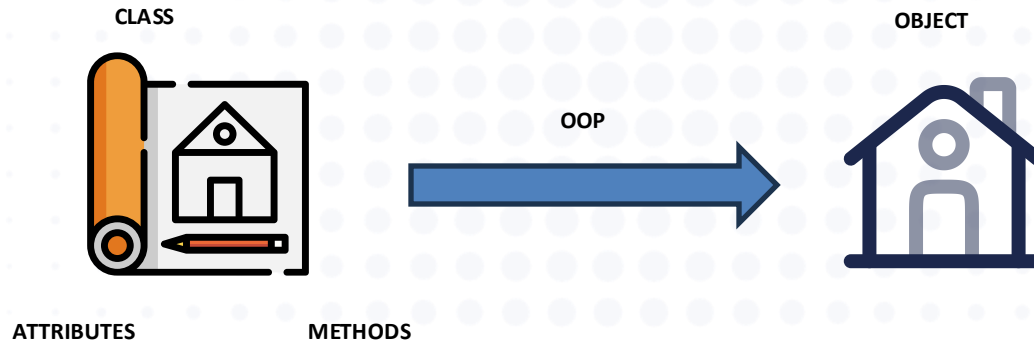
in python “overloading” means redefining what `+`, `>`, `==`, etc. do for your objects through **dunder methods**. Remember: Python is “simple”, nothing happens at compile time, every operator is just a function call under the hood.

Operator	Method Name	Usage Example
+	<code>__add__(self, other)</code>	<code>a + b</code>
-	<code>__sub__(self, other)</code>	<code>a - b</code>
*	<code>__mul__(self, other)</code>	<code>a * b</code>
/	<code>__truediv__(self, other)</code>	<code>a / b</code>
==	<code>__eq__(self, other)</code>	<code>a == b</code>
<code>len()</code>	<code>__len__(self)</code>	<code>len(obj)</code>
<code>[]</code>	<code>__getitem__(self, key)</code>	<code>obj[key]</code>
<code>in</code>	<code>__contains__(self, item)</code>	<code>item in obj</code>
<code>str()</code>	<code>__str__(self)</code>	<code>print(obj)</code>
<code>repr()</code>	<code>__repr__(self)</code>	<code>repr(obj)</code>
<code>call()</code>	<code>__call__(self, *args)</code>	<code>obj()</code>
<code>del</code>	<code>__del__(self)</code>	<code>del obj</code>

OBJECT ORIENTED PROGRAMMING

WHY IS IT USED SO MUCH?

OBJECT-ORIENTED PARADIGM



OBJECT LIFECYCLE in PYTHON

`object.__new__(cls[, ...])`

Called to create a new instance of class `cls`. `__new__()` is a static method (special-cased so you need not declare it as such) that takes the class of which an instance was requested as its first argument. The remaining arguments are those passed to the object constructor expression (the call to the class). The return value of `__new__()` should be the new object instance (usually an instance of `cls`). [...]

`object.__init__(self[, ...])`

Called after the instance has been created (by `__new__()`), but before it is returned to the caller. The arguments are those passed to the class constructor expression. If a base class has an `__init__()` method, the derived class's `__init__()` method, if any, must explicitly call it to ensure proper initialization of the base class part of the instance; for example: `super().__init__(args...)`. [...]

`object.__del__(self)`

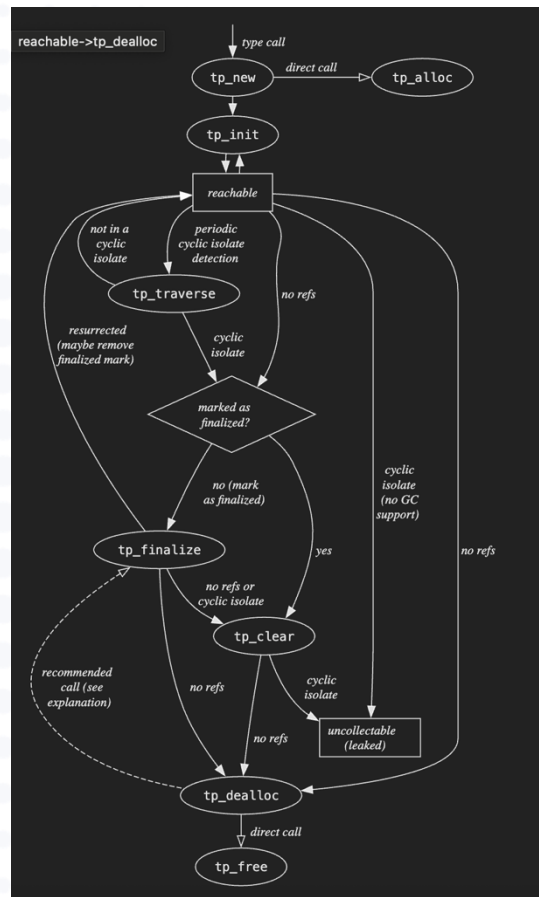
Called when the instance is about to be destroyed. This is also called a finalizer or (improperly) a destructor. If a base class has a `__del__()` method, the derived class's `__del__()` method, if any, must explicitly call it to ensure proper deletion of the base class part of the instance. [...]

```
class Overload_Me:
    def __new__(cls): print("Creating instance");
    return super().__new__(cls)

    def __init__(self): print("Initializing instance")

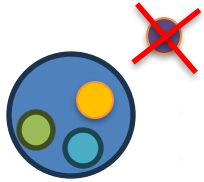
    def __del__(self): print("Destroying instance")
```

```
overload_me_object = Overload_Me()
del overload_me_object
```

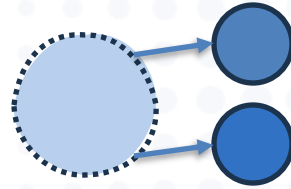


<https://docs.python.org/3/c-api/lifecycle.html>

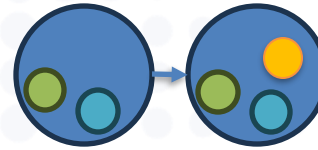
OBJECT AND CLASSES BASIC PROPERTIES



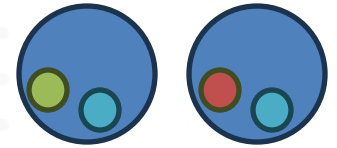
Encapsulation



Abstraction

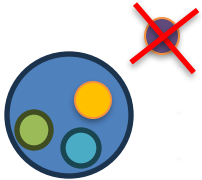


Inheritance



Polymorphism

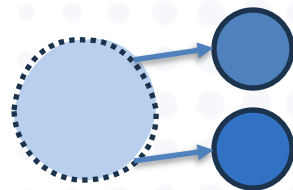
OBJECT AND CLASSES BASIC PROPERTIES



Encapsulation

**EVERYTHING IS CONTAINED
INSIDE AN OBJECT**

OBJECT AND CLASSES BASIC PROPERTIES



Abstraction

**THE FUNCTION COULD BE
DESCRIBED REGARDLESS OF THE
IMPLEMENTATION**

IF I NEED A FUNCTION TO TALK TO PEOPLE OVER LONG DISTANCES



[liberpraker](#) - Own work

[CC BY-SA 4.0](#)

•File: TTR RTT 56B Telephone 2.jpg
•Created: 16 December 2012
•Uploaded: 17 December 2012



[Gustavo Belemmi](#) - Own work

[CC BY-SA 4.0](#)

•File: Antique toy walkie-talkie.jpg
•Created: 13 July 2021
•Uploaded: 14 July 2021



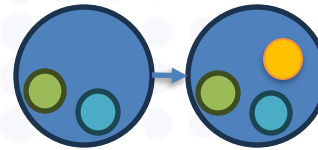
© Raimond Spekking / CC BY-SA 4.0 (via Wikimedia Commons)

[CC BY-SA 4.0](#)

•File: Dell Streak-9014.jpg
•Created: 22 June 2020
•Uploaded: 28 June 2020

OBJECT AND CLASSES BASIC PROPERTIES

I CAN EXTEND THE
FUNCTIONALITIES OF A CLASS

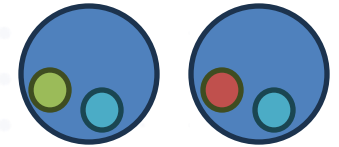


Inheritance



OBJECT AND CLASSES BASIC PROPERTIES

I CAN OVERRIDE THE
FUNCTIONALITIES OF A CLASS



Polymorphism

WORKING TOGETHER – DEFINE CLASSES WITHOUT CODE



METHOD SIGNATURE:

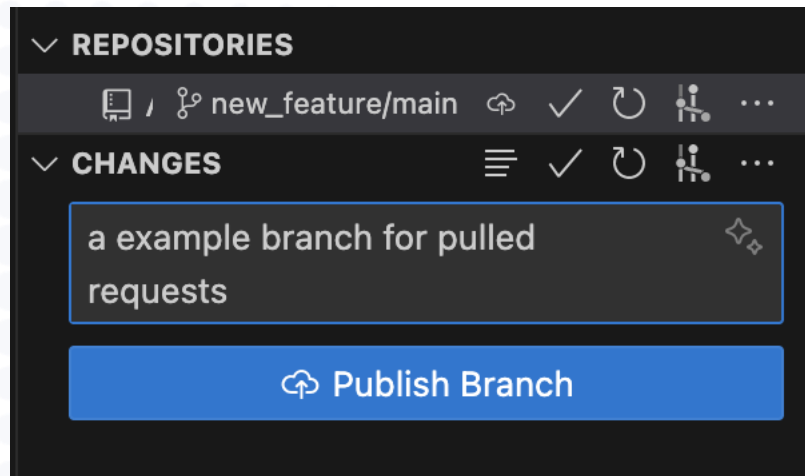
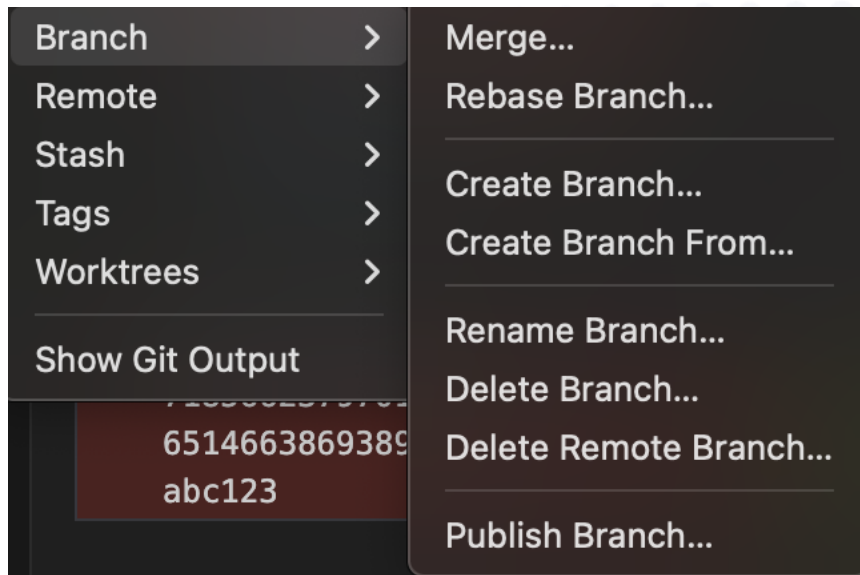
```
def NAME(param1: type, param2: type, ...) -> return type
```

Brief description:

What this function does.

WORKING TOGETHER – GIT PULLING REQUESTS

*1. CREATE A NEW BRANCH FROM THE MAIN
CALL IT LIKE `new_feature/category`*



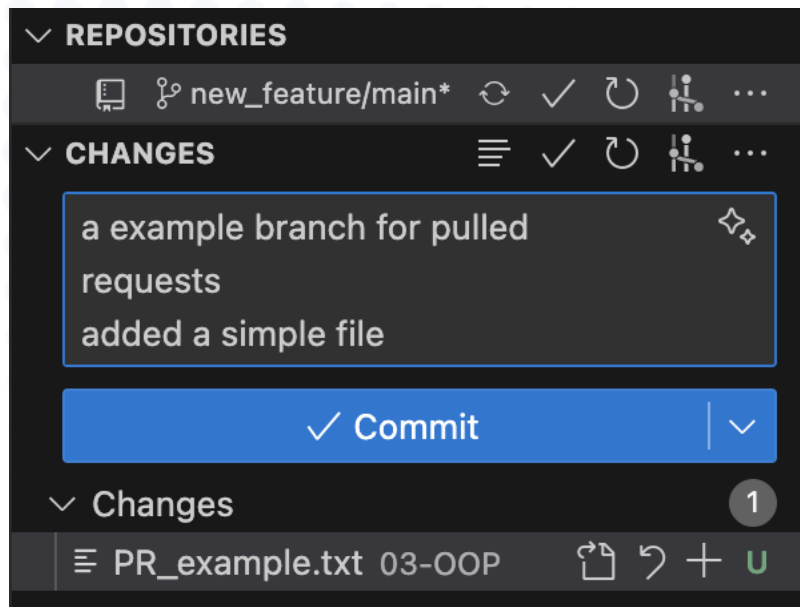
`new_feature/main`

Please provide a new branch name (Press 'Enter' to confirm or 'Escape' to cancel)

WORKING TOGETHER – GIT PULLING REQUESTS

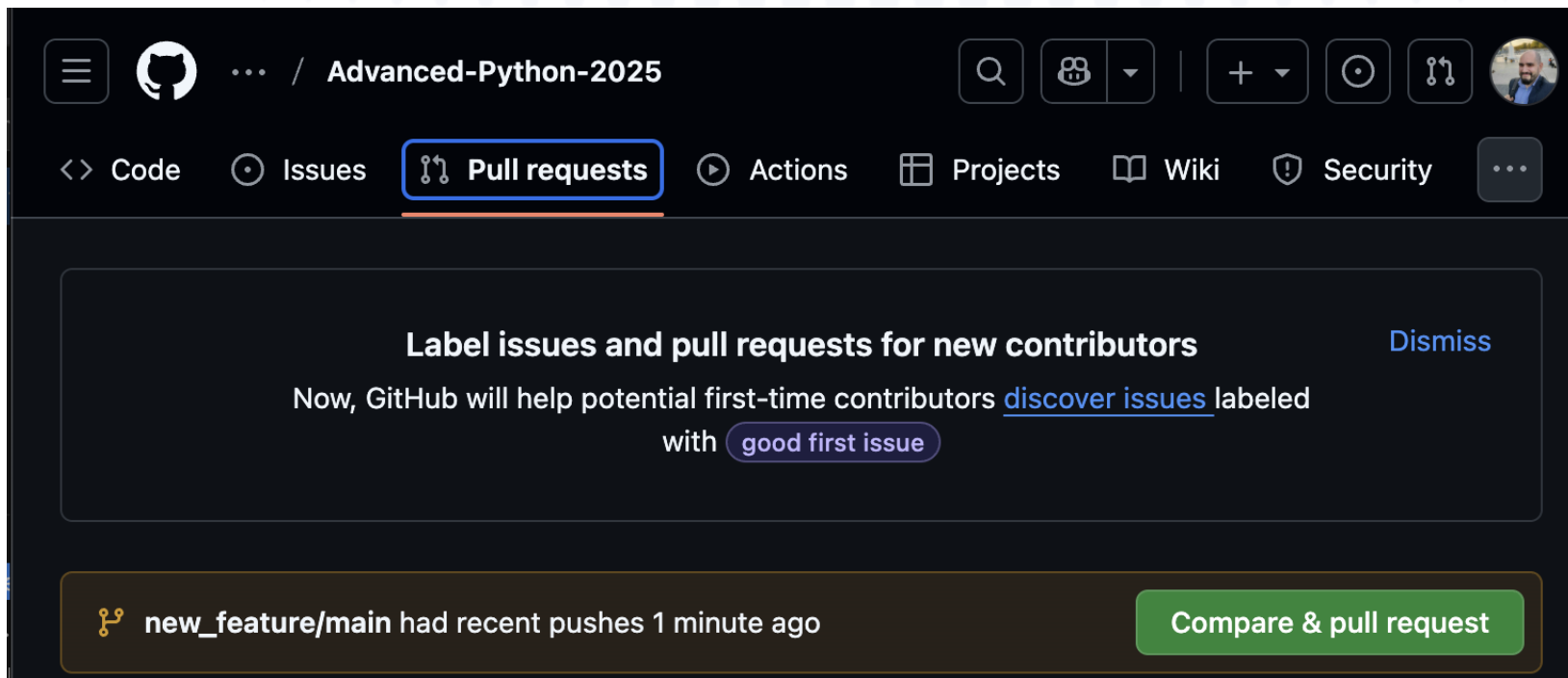
- a example branch... new_feature/main
- exercise solved on less... origin/main
- Added some examples on dunder metho...
- Added lesson 3 on OOP Marco Prenassi
- added multi file support Marco Prenassi
- Lesson 02 initial commit Marco Prenassi
- added 01-Intro lecture code Marco Prenassi

2. *CHECKOUT* IN THAT BRANCH,
create/edit
and TEST the new branch and then
COMMIT and *PUSH*!



WORKING TOGETHER – GIT PULLING REQUESTS

2. In github you get a notification of the branch, you can do "Compare and send a Pull request"




The screenshot shows the GitHub web interface for the repository 'Advanced-Python-2025'. The 'Pull requests' tab is highlighted with a blue border. A notification banner at the top states: 'Label issues and pull requests for new contributors'. Below this, it says: 'Now, GitHub will help potential first-time contributors [discover issues](#) labeled with [good first issue](#)'. At the bottom, a notification for the 'new_feature/main' branch indicates it had recent pushes 1 minute ago, with a green button labeled 'Compare & pull request'.

Advanced-Python-2025

Code Issues **Pull requests** Actions Projects Wiki Security

Label issues and pull requests for new contributors [Dismiss](#)

Now, GitHub will help potential first-time contributors [discover issues](#) labeled with [good first issue](#)


 new_feature/main had recent pushes 1 minute ago [Compare & pull request](#)

WORKING TOGETHER – GIT PULLING REQUESTS

2. In github you get a new Pull request, compare it and check if there are some merge issue.

Open a pull request


Create a new pull request by comparing changes across two branches. If you need to, you can also [compare across forks](#). [Learn more about diff comparisons here](#).

 base: main ▾

← ...

compare: new_feature/main ▾




✓ **Able to merge.** These branches can be automatically merged.




Add a title


a example branch for pulled requests


Add a description

Write Preview H B I    ...

added a simple file

Reviewers 
No reviews


Assignees 
No one—[assign yourself](#)


Labels 
None yet

WORKING TOGETHER – GIT PULLING REQUESTS

3. The CODE MAINTAINER (e.g., the team leader) check, approve and merge the Pull Request

1

**No conflicts with base branch**
Merging can be performed automatically.


Merge pull request  You can also merge this with the command line.
[View command line instructions.](#)


2


a example branch for pulled requests #1 Edit <> Code

Merged marcopenassi merged 1 commit into `main` from `new_feature/main` now

Conversation 0 Commits 1 Checks 0 Files changed 1 +1 -0

 marcopenassi commented `now` Member ...
added a simple file

 a example branch for pulled requests ee42530

 marcopenassi merged commit `f80073b` into `main` `now` Revert


Reviewers
No reviews
Still in progress? [Convert to draft](#)

Assignees
No one—assign yourself

Labels
None yet

Projects

3

Graph	Description
	<code>main</code> <code>origin</code> <code>origin/HEAD</code> a example b...
	<code>new_feature/main</code> <code>origin</code> a example b...

exercice solved on lesson 3

Try and Fail by design: Exceptions

Exceptions in Python

python stops execution when something unexpected happens,
like a missing file, wrong type, or division by zero.

Sometime, the unexpected is expected, and we need to manage this uncertainty in clean and orderly way.

```
try:
    with open("data.txt", "r") as f:
        content = f.read()
        print(content)
except FileNotFoundError:
    print("file not found")
except Exception as e:
    print(f"unexpected error: {e}")
```

This is DANGEROUS
Don't be afraid to crash





Finanziato
dall'Unione europea
NextGenerationEU



Ministero
dell'Università
e della Ricerca



Italiadomani
PIANO NAZIONALE
DI RIPRESA E RESILIENZA



E-ARGO



CERIC

Thank you

This Pilot training activity has been funded by the European Union – NextGenerationEU within the PNRR projects funded pursuant to Article 11, paragraph 1, of Notice 594/2024:

- “NFFA-DI cod. IR0000015, Missione 4, “Istruzione e Ricerca” – Componente 2, “Dalla ricerca all’impresa” – Linea di investimento 3.1, “Fondo per la realizzazione di un sistema integrato di infrastrutture di ricerca e innovazione” – Azione 3.1.1, “Creazione di nuove IR o potenziamento di quelle esistenti che concorrono agli obiettivi di Eccellenza Scientifica di Horizon Europe e costituzione di reti” (CUP B53C22004310006).
- “EFC cod. SSU2024-00002, Missione 4 “Istruzione e ricerca” - Componente 1, “Potenziamento dell’offerta dei servizi all’istruzione: dagli asili nido all’università” - Investimento 3.4 “Didattica e competenze universitarie avanzate” - Sub-Investimento “Rafforzamento delle scuole universitarie superiori” (CUP: G97G24000100007).