ILP 2020 – W1S1
Getting started

Matthieu DE MARI – Singapore University of Technology and Design

SINGAPORE UNIVERSITY OF
TECHNOLOGY AND DESIGN

A quick word about me

- Matthieu (**Matt**) DE MARI
- Lecturer at SUTD (Python, Deep Learning, AI, and more)
- Information Systems Technology and Design (ISTD) pillar/faculty
- PhD from CentraleSupelec (France)

- Email: matthieu_demari@sutd.edu.sg
- Office @ SUTD: 1.702.27

Outline (Week1, Session1 – W1S1)

- About this course: syllabus, objectives, Zoom, eDimension, practice, grading, etc.

- What is programming?
- Key concepts about programming and computer science.
- Programming languages.

- Installing and configuring Python, and extra packages.
- Our first programs!

Objectives of this Summer School

Objectives:

- Give the students an introduction to Computer Science,
- Programming,
- and Python.

Delivery:

- 3x 2h-lessons per week
- Lessons include a bit of theory (PPT slides) and practice activities (in Jupyter Notebooks)

Topics

- Week1 Session 1 (W1S1): Getting started, key concepts, configuring and installing Python
- W1S2: Variables, math operators, comments, printing and getting
- W1S3: None type, Boolean types and functions
- W2S1: If, elif, else, while, break statements
- W2S2: For loops, generators and recursion
- W2S3: The list type
- W3S1: Numpy (part1), and imports
- W3S2: Everything about strings
- W3S3: Tuples, sets, dictionaries and object-oriented thinking

Topics

- W4S1: Debugging, errors, asserts and time
- W4S2: MidTerm! (date to be confirmed)
- W4S3: Midterm debrief
- W5S1: Randomness and Numpy (part2)
- W5S2: Algorithmic complexity, the sorting problem example
- W5S3: Files and math computations
- W6S1: Mini Project
- W6S2: Final exam! (date to be confirmed)
- W6S3: Final exam debrief and final discussions

E-learning and Zoom

At the moment, no students on campus @ SUTD.

- All classes are to be held online on **Zoom**.
- If that changes, I will let you know.

Each lesson will be given twice, 3 lessons per week.

- **Group A:** Tue (4pm-6pm), Wed (4pm-6pm), Fri (4pm-6pm).
- **Group B:** Mon (1pm-3pm), Wed (1pm-3pm), Fri (1pm-3pm).

If you cannot attend a group A lesson, you can join the group B one on that same week. And vice versa.

E-learning and Zoom

Group A: Tue (4pm-6pm), Wed (4pm-6pm), Fri (4pm-6pm).

- Link: https://sutd-edu-sg.zoom.us/j/94842370566?pwd=VEl0b3ZNOGFtZXFUL3RYc0hCVzZOdz09
- Password: 505161

Group B: Mon (1pm-3pm), Wed (1pm-3pm), Fri (1pm-3pm).

- Link: https://sutd-edu-sg.zoom.us/j/99940763507?pwd=VWJCMStteW8xK1AzSXJaV3pwSnVSUT09
- Password: 209098

E-learning and Zoom

A bit of advice… Try using two screens!

- If you can, have one screen for the zoom screen sharing (slides, and demo)
- And have one screen where you get to play with the activities notebooks, and your own slides.

If you do not own a desktop/laptop and an extra monitor, I suggest to download zoom on your smartphone and have the meeting displayed on your phone, while coding on your laptop/desktop.

Edimension

Teaching materials

- PPT/PDF contain the lecture materials (PPT preferred)
- Activities notebooks and their answers
- The teaching materials will be uploaded on eDimension and made available on the same day.
- https://edimension.sutd.edu.sg/

Also, Zoom links posted to eDimension, just in case.

Homeworks, extras and exams

Practice?

- In-class activities: activities, done together during online lessons.
- Solutions are provided on other notebooks.

Need some extra practice?

- Homeworks: nope.
- Extra practice: basic exercises and notions, to practice the concepts seen in class a bit more.
- Extra challenges: advanced versions of the activities discussed in class.
- None of them are mandatory. Solutions are provided.

Exams

Midterm (50%) – On W4S2 (to be confirmed). Feedback on W4S3.

- Covers notions in W1-W3.
- Theory MCQ.
- A few practice questions.

Final (50%) – On W6S2 (to be confirmed). Feedback on W6S3.

- Covers notions in W1-W5.
- Theory MCQ.
- A few practice questions.

Survey

- During this class, I might often use online “surveys”.
- These help me check your understanding of this class and adjust accordingly… Please fill them!

- Speaking of... **Here is your first survey: what is “programming”?**

https://docs.google.com/forms/d/e/1FAIpQLSejSKnRZYR-2kN1MlcEV0_5KNh0pu6V6JOaQsqS9Vo5iHEF1A/viewform?usp=sf_link

Programming: definition

- **<u>Definition (Programming):</u>**
  Programming refers to the process of designing and building an executable computer program, to accomplish a specific computational task.

  It involves tasks such as
  - analysis,
  - designing **algorithms**,
  - and implementing said **algorithms** in a chosen programming language (a.k.a. **coding**).

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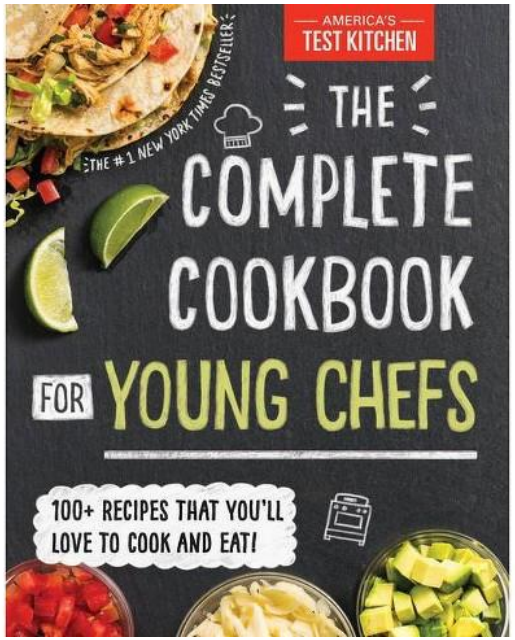
  - designing **algorithms**,
  - and implementing said **algorithms** in a chosen programming language (a.k.a. **coding**).

- **<u>Layman definition (Programming):</u>** **Programming** consists of defining a sequence of instructions that the computer must follow to accomplish a task.

Programming: some analogies

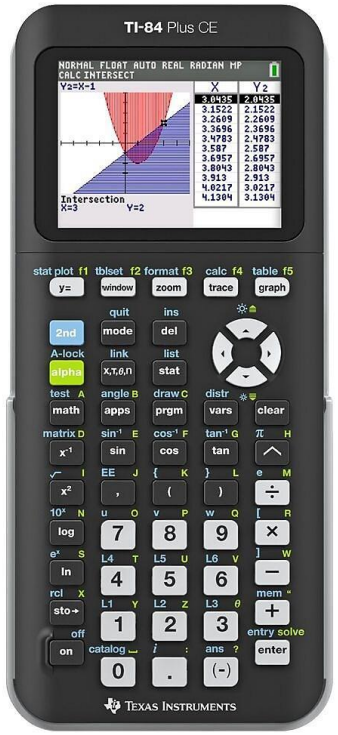
- Think of it as a food **recipe** book! A recipe requires you to follow and execute a set of instructions to cook a recipe from scratch!

Raw ingredients → **Recipe instructions** → A nice dish as a result



Programming: some analogies

- Or a **sequence of operations** you would normally do on a calculator to find a result.



- **Example problem:** compute the area of a circle with radius 10.
  - Type 10,
  - Type multiply key,
  - Type 10,
  - Press equal/enter key,
  - Type multiply key,
  - Type π,
  - Press equal key again,
  - You have reached your result.

Algorithm: definition

- **<u>Definition (Algorithm):</u>** An **algorithm** is a finite sequence of instructions, typically used to solve a class of problems or perform a computation task.

  When executed, on a provided set of inputs, it will proceed through a set of well-defined states and will eventually produce an output.

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ALGORITHM

The life of a programmer

1. **Identify a problem.**
2. **Come up with a general algorithm to solve it.**
   - Step-by-step instructions.
   - Think of it as a ‘recipe’ or a ‘flowchart’.
3. **Represent this algorithm as a program, using a chosen programming language.**
4. **Execute the program on a computer!**

- Type 10,
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ALGORITHM

python™

Quick question

→ **Who is considered the inventor of computers and "programming"?**

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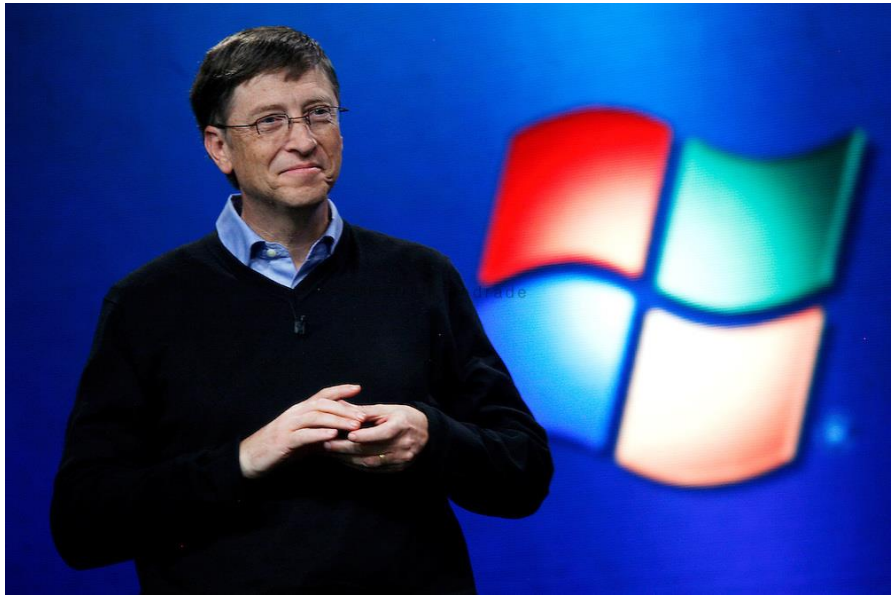
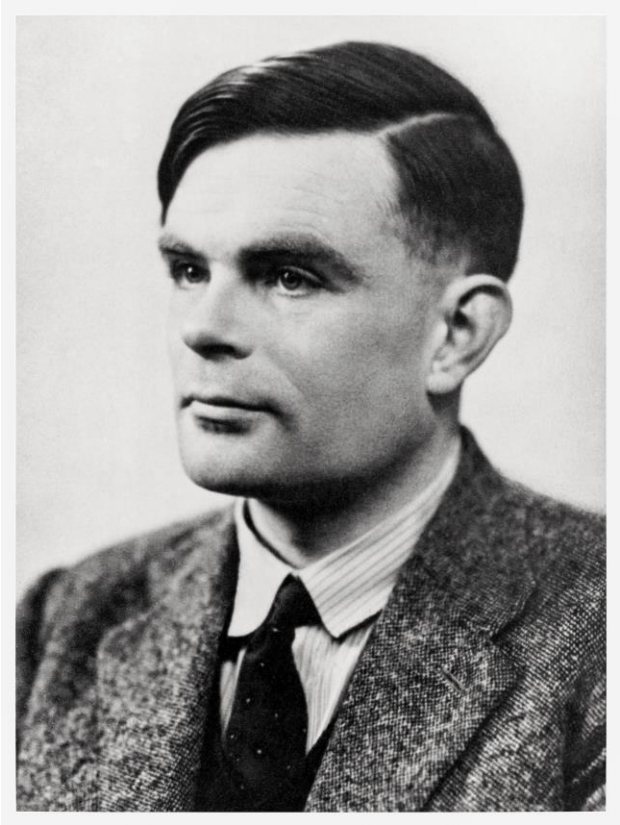
Hint: it is NOT one of the persons below.



The “father” of computer science

Alan Mathison Turing (1912–1954) was an English mathematician, computer scientist, logician, cryptanalyst, philosopher, and theoretical biologist.



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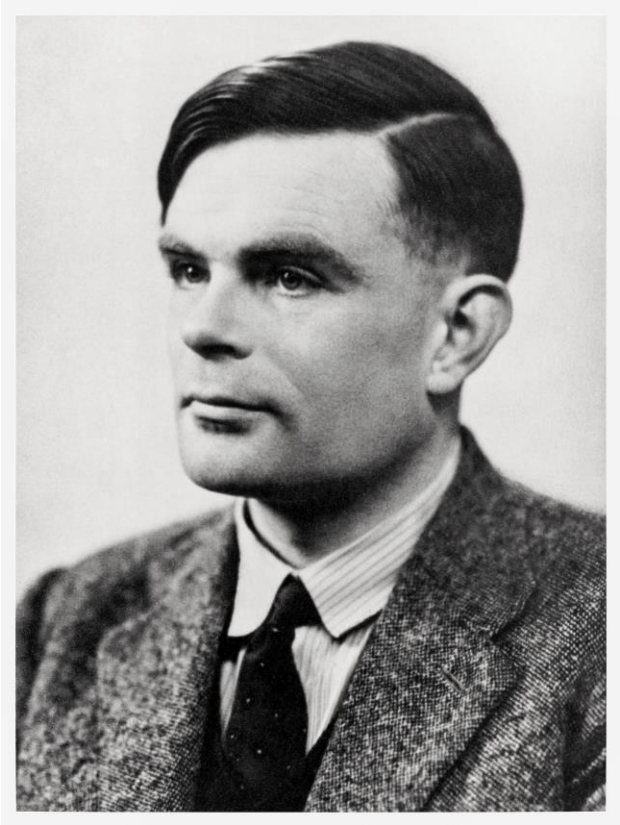
- Turing was highly influential in the development of theoretical computer science, formalized algorithmic concepts, and created the first Turing machine, which can be considered the first model of a general-purpose computer.



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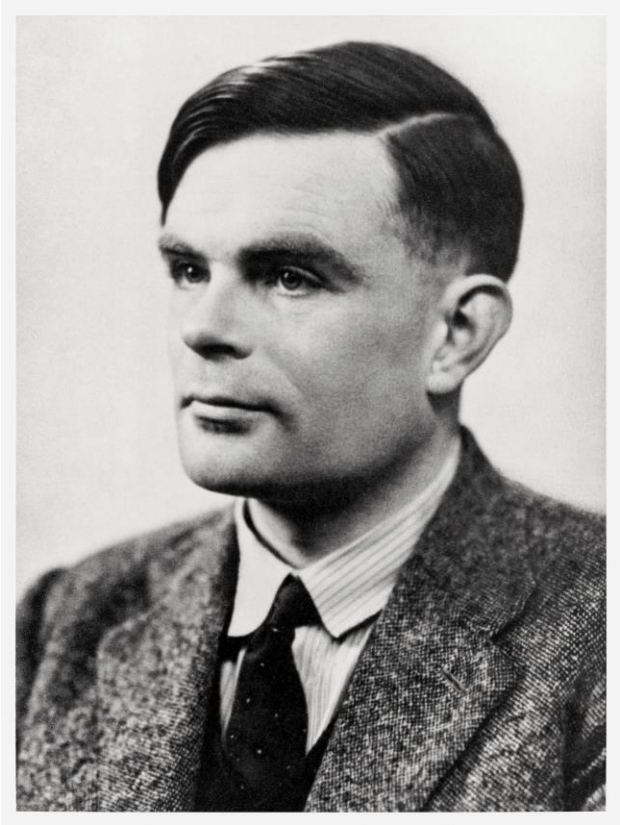
- During World War 2, he came up with an idea of a “computer-like” machine, to decode encrypted transmissions from the German army.
- Thanks to his decryption device, it has been estimated the war in Europe was shortened by more than two years and saved over 14 million lives.



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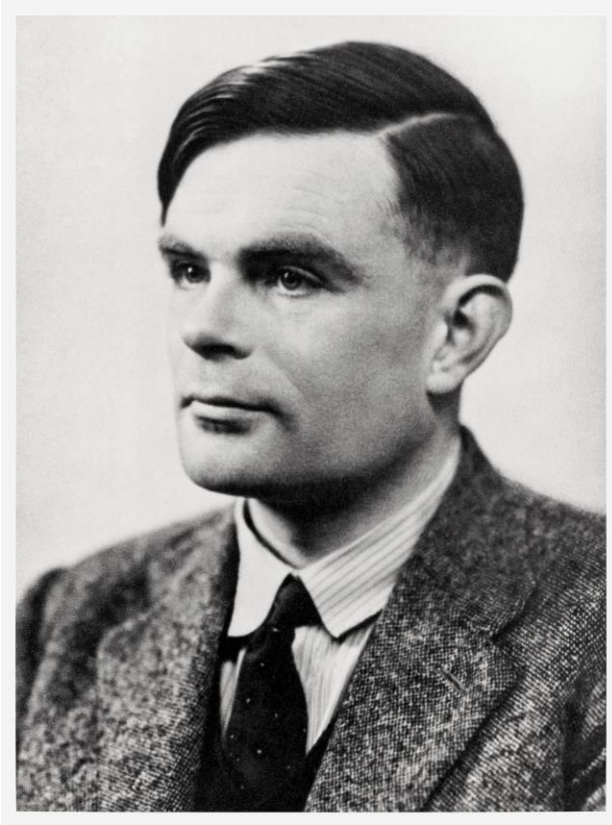
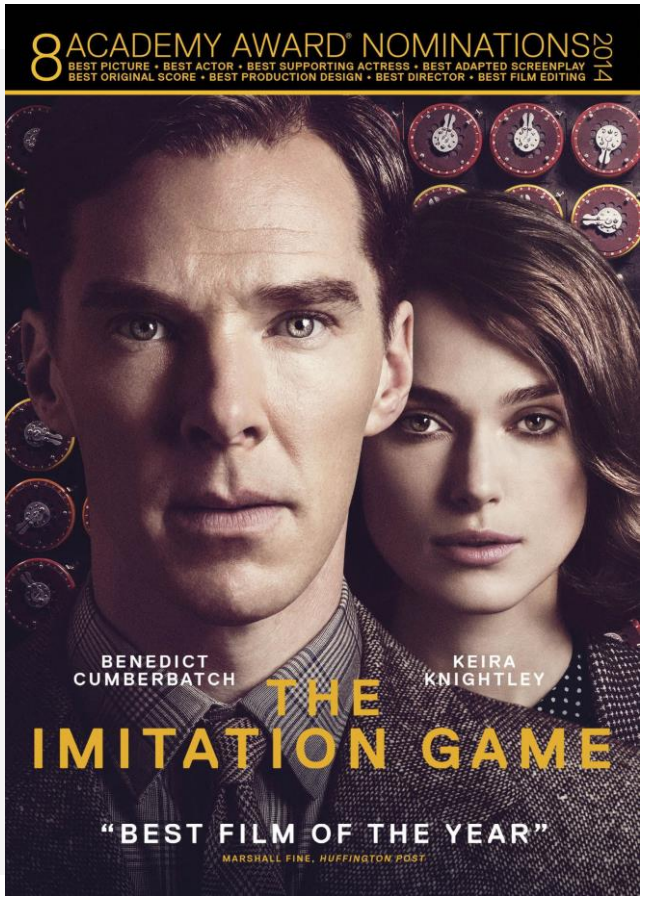
- Learn more about Alan Turing, by watching **The Imitation Game** movie.





About your computer

Your computer is good at doing two, and **only** two, things

1. **Perform computational tasks (calculations)**, as described by an algorithm provided by a human to the computer.
2. **Remember the results of these computational tasks**, by storing them in its internal memory (and eventually retrieving these results later on, by accessing its memory)

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And that is it.

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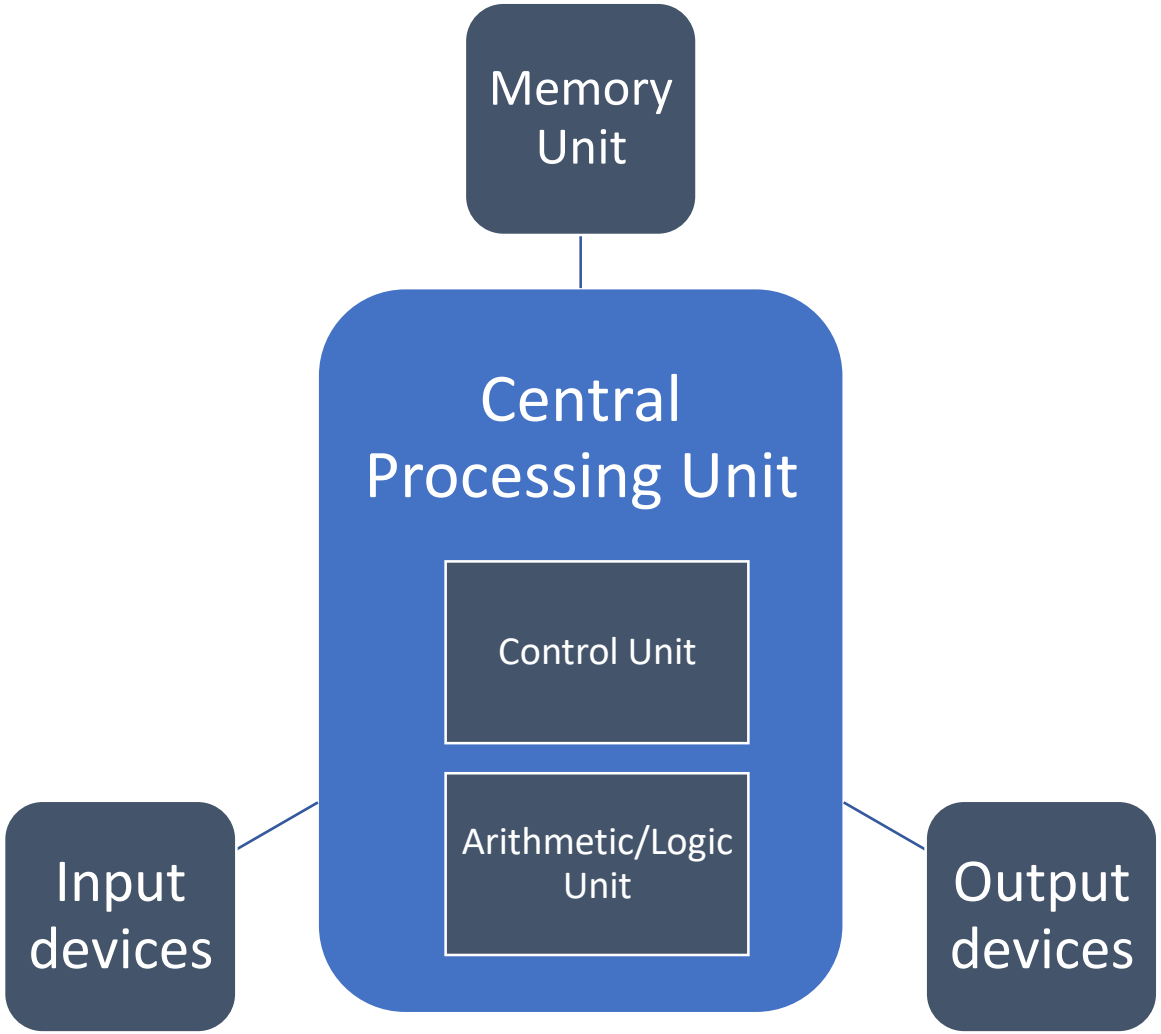
Because all operations performed by computers nowadays can be broken down to combinations of both aforementioned operations.

The Von Neumann architecture

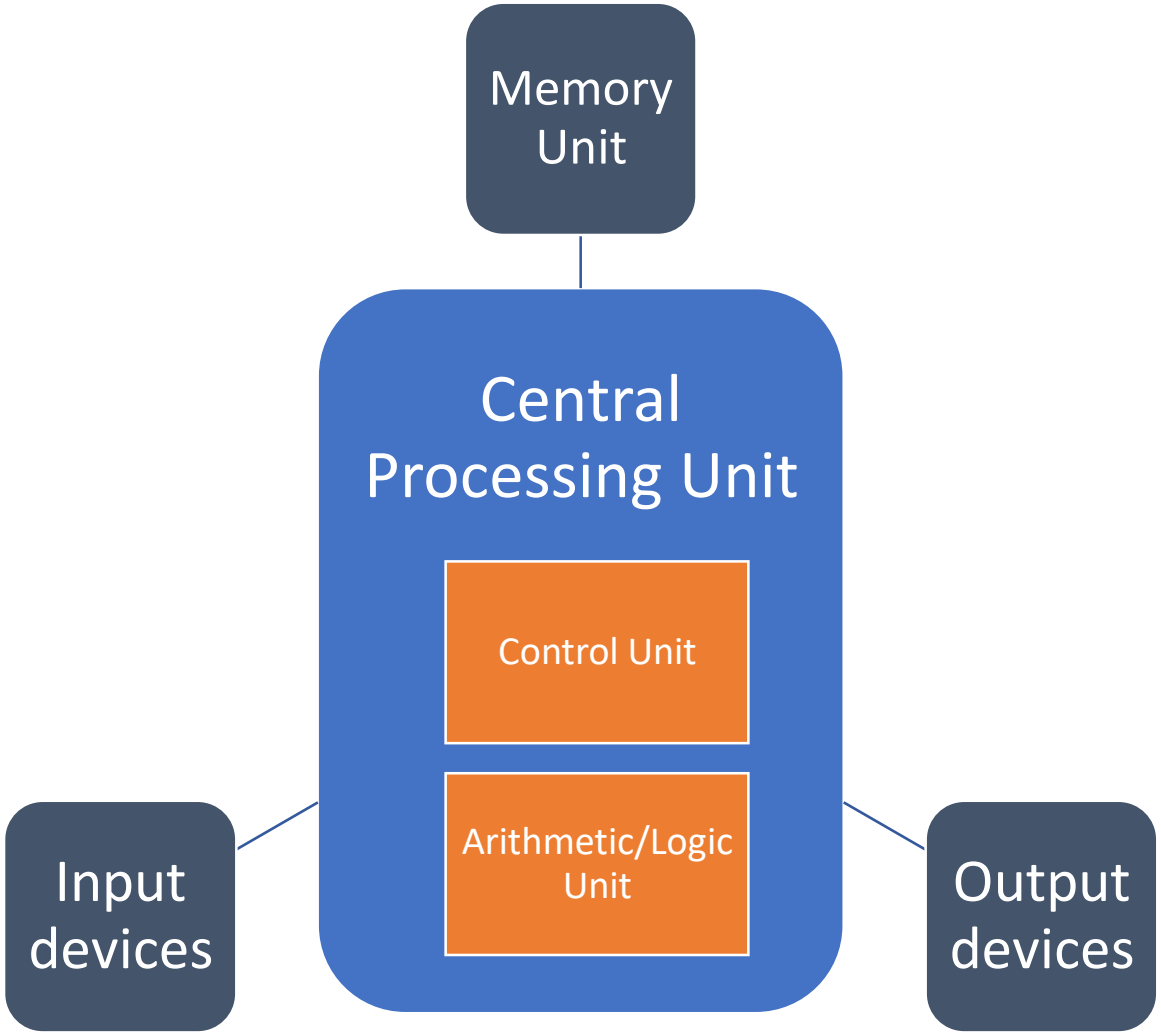
- **Definition (Von Neumann architecture):** The Von Neumann architecture describes one of the first architectures for a computer.



The Von Neumann architecture

It first consists of a **Central Processing Unit (CPU)**, which itself consists of…

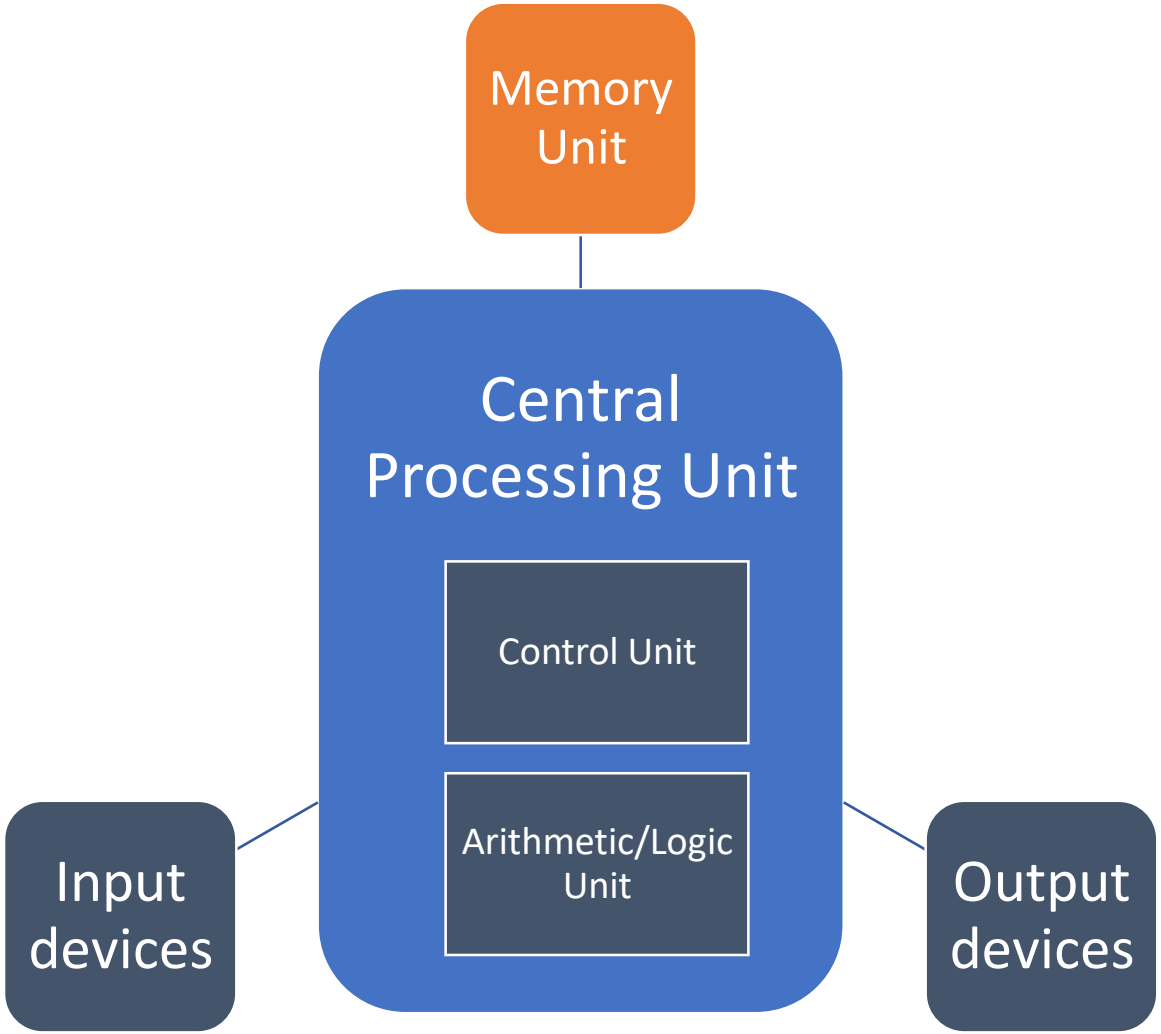
- An **Arithmetic/Logic Unit** (in charge of dealing with instructions, typically math operations, in binary 0/1),
- And **a Control Unit** (in charge of the hardware and communication between different hardware elements)



The Von Neumann architecture

It also contains…

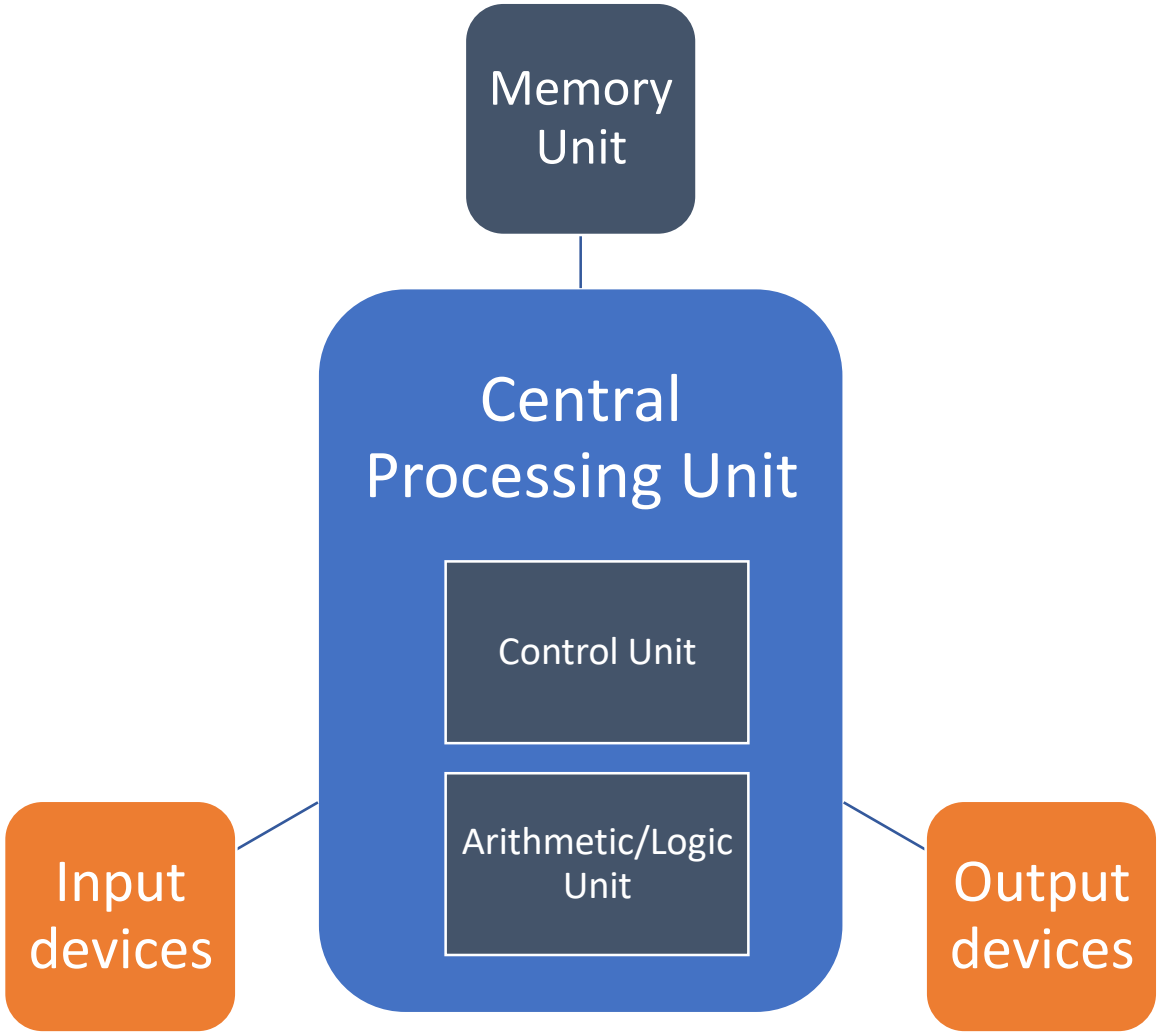
- A **Memory Unit** (for storing and retrieving results from previous computational tasks, using binary formatting 0/1),



The Von Neumann architecture

It also contains…

- A **Memory Unit** (for storing and retrieving results from previous computational tasks, using binary formatting 0/1),
- **Inputs and Outputs Devices** (e.g. mouse, keyboard, screen, microphone, webcam, etc.).



The problem of dealing with binary and the need for programming languages

- **Observation:** in a computer, all operations (computational and memory tasks) and are performed in **binary**.

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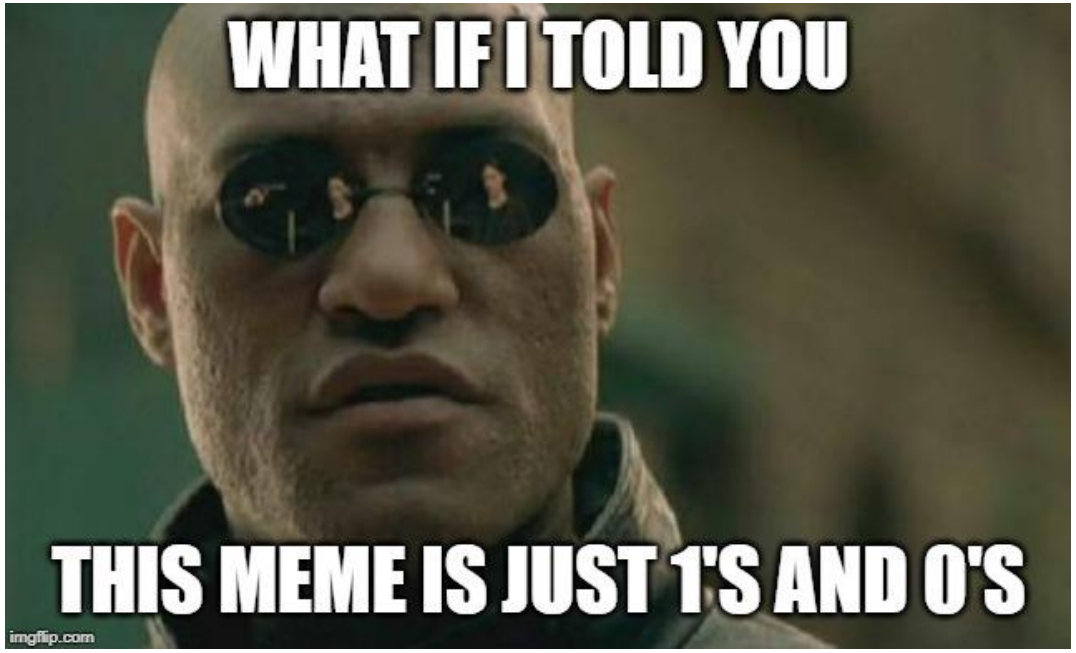
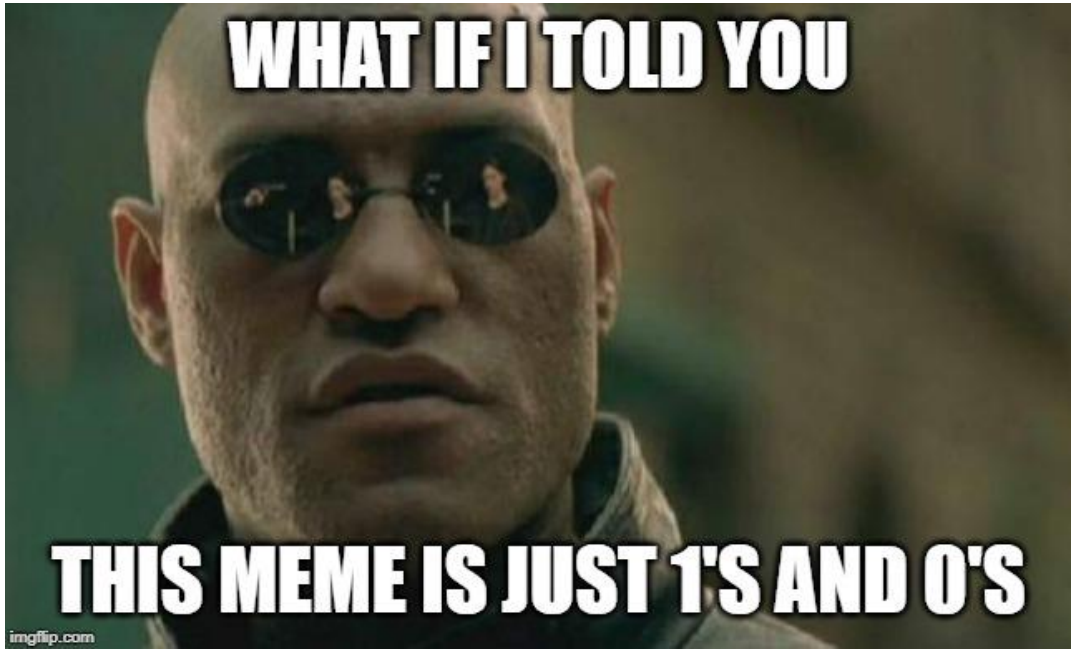


The problem of dealing with binary and the need for programming languages

- **Observation:** in a computer, all operations (computational and memory tasks) and are performed in **binary**.

- **Problem:** binary is heavy and difficult to read for humans.
- **Example:** “Matthieu”, in binary, is “01001101 01100001 01110100 01110100 01101000 01101001 01100101 01110101“.



The problem of dealing with binary and the need for programming languages

- **Observation:** in a computer, all operations (computational and memory tasks) and are performed in **binary**.

- **Solution:** find an intermediate language, readable by humans, to address the computer.
  - **High-level language:** closer to human language
  - **Low-level language:** closer to binary

Generations	Languages	Characteristics
First-generation languages (1954 – 1958)	FORTRAN I, ALGOL 58, Flowmatic, IPL V	Mainly used for mathematical calculations; consists only of global data and sub-programs.
Second-generation languages (1959 – 1961)	FORTRAN II, ALGOL 60, COBOL, Lisp	Use extended to business applications; artificial intelligence; subroutines, block structure, data types introduced.
Third-generation languages (1962 – 1970)	PL/1, ALGOL 68, Pascal, Simula	Use extended to wider applications; ideas of modules and data abstraction introduced.
The generation gap (1970 – 1980)	C, FORTRAN 77	Many languages invented with few surviving; small executables, thrust towards standardization.
Enhanced popularity of object-orientated languages (1980 – 1990)	Smalltalk 80, C++, Ada83, Eiffel	Languages derived from previous ones; the idea of a class as a basic unit of abstraction.
Emergence of frameworks (1990 – present)	Visual Basic, Java, Python, J2EE, .NET, Visual C++, Visual Basic .NET	Widespread use of integrated development environments (IDE); focus on Web-based systems.

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Python: what is it?

About Python: Python is an interpreted, high-level, general-purpose programming language.

- Created by Guido van Rossum and first released in 1991.
- Currently on its **v3**, since **2008**.
- Python's design philosophy emphasizes code **readability**.
- Its language constructs aim to help programmers write clear, logical code for small and large-scale projects.

Why learn Python?

- **High-level language:** easy to write and read, and therefore well-suited for beginners.

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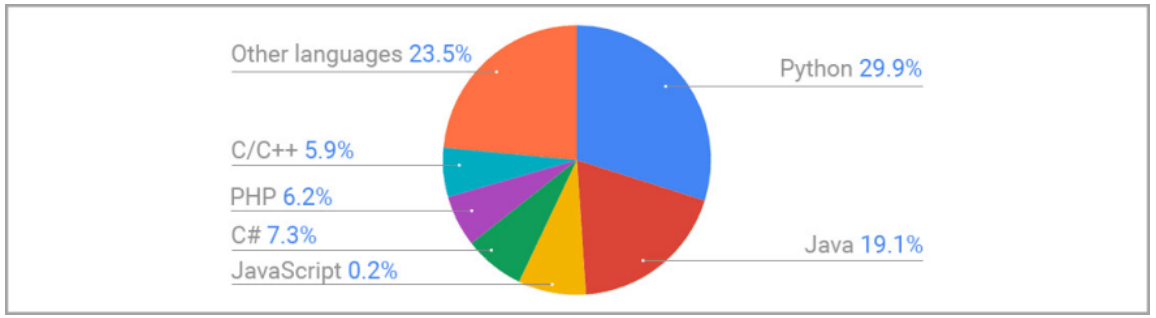
- **Dynamic typing:** in layman terms, Python is able to manage the data saved to memory, in an automated and efficient fashion, without human intervention.

- **Python is the #1 language for data science and AI at the moment:** several frameworks such as Tensorflow (Google AI), Pytorch (widely used in academic research on AI), etc.



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- **Python is widely used in IT companies:** see Figure on the right.
- **Also, high interoperability with other languages:** Jumping to or including another language (Java, C, SQL, etc.) is easy, once you know Python.

→ Overall, Python is a good **entry point** for beginners in both programming and computer science, and therefore the first language we teach in SUTD.

Installing Python

- In this class, we will use **Python 3.8(.3)** (latest stable version as on the 20th of May 2020).
- Download it here (for 32/64-bit Windows and Mac users, Linux users can get it via apt-get or SoftwareCenter)

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

Installing Python

Install it now!

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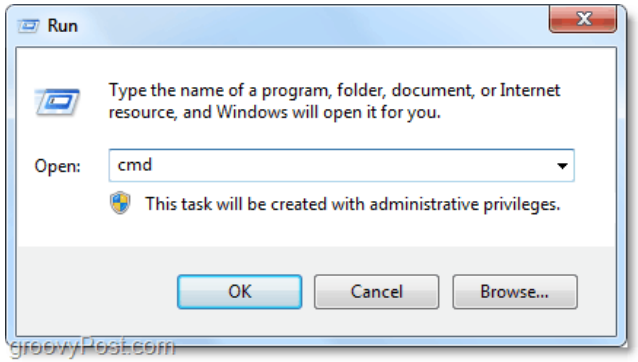
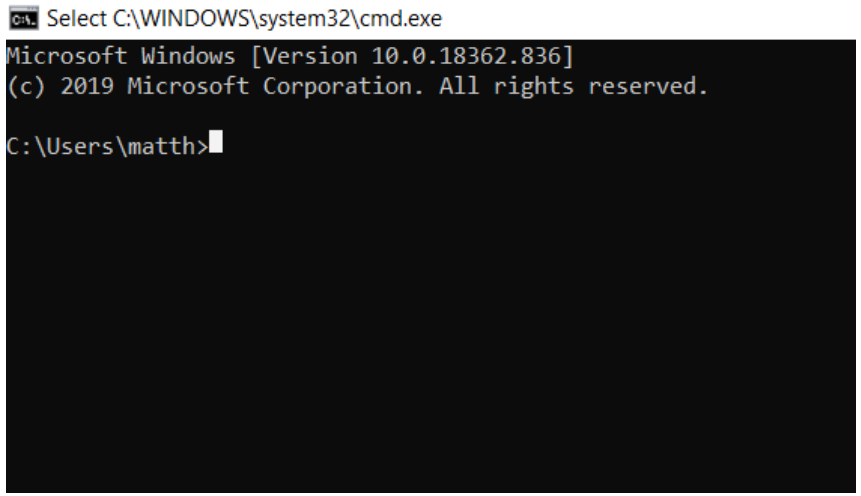
Opening a console (Windows)

- Check your installation has completed appropriately, by trying to open a **console**.

- **Windows:** the cool way.

1. Press simultaneously **Windows key + R**,
2. then type **cmd**, and press **Enter.**

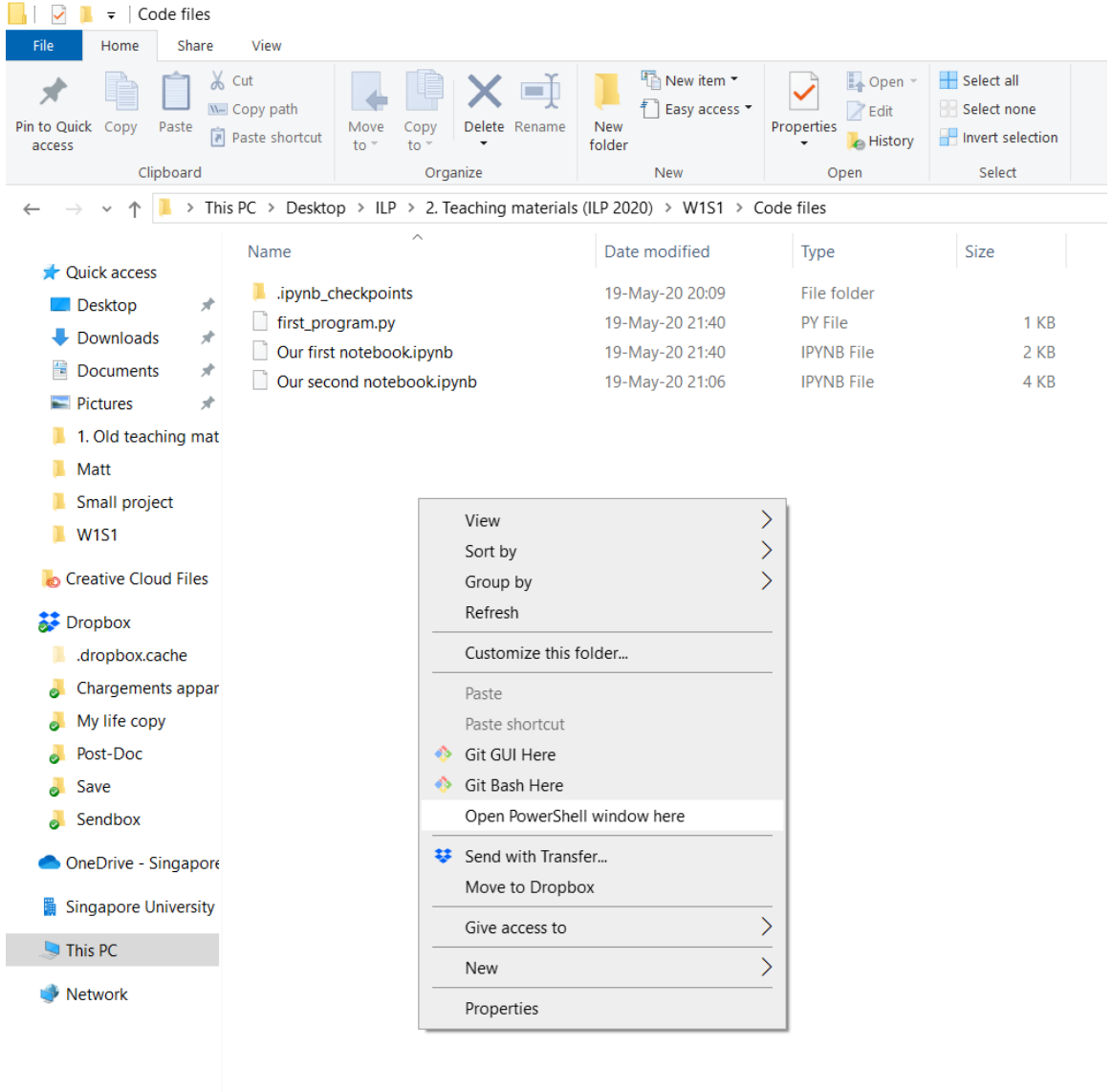




Opening a console (Windows – option 2)

- **Windows option 2:** faster and more convenient way, in my opinion

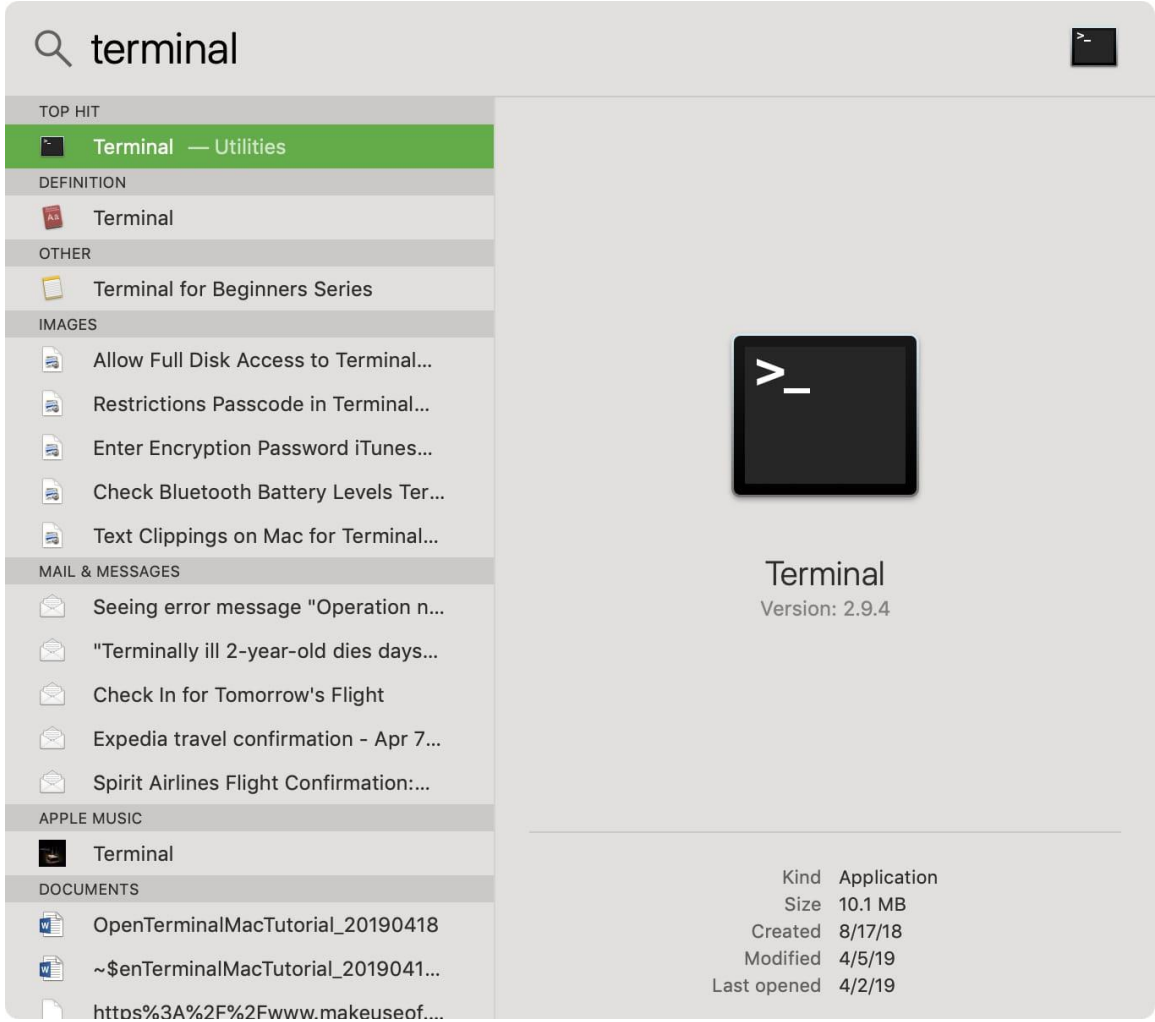
1. **Open an explorer** in the folder you attempt to work in.
2. **Hold shift** and **right-click** in an empty space of the explorer window.
3. **Choose "Open Powershell window here".**



Opening a console (Mac OS)

- **Mac:** roughly the same procedure

1. Press simultaneously **Command key + Space**,
2. Then type **Terminal**,
3. It should appear as your top result, click it

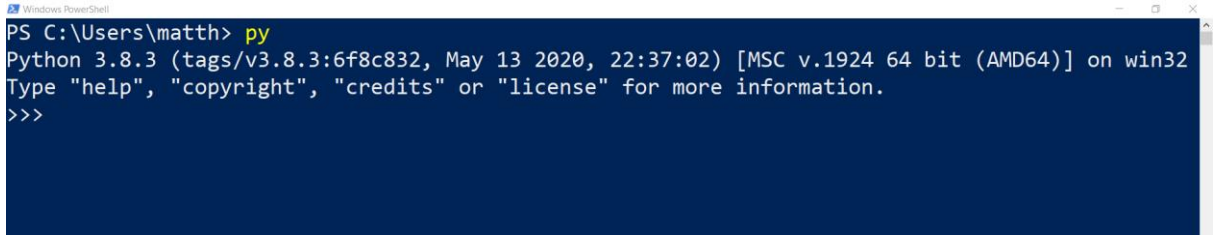


Your first run of Python!

Start python by **typing one** of the following commands in the console and press **Enter!**

(Note: one of these should work, might vary depending on your machine!)

- **py (most frequent one, works in my case)**
- py3
- python
- python3



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```
PS C:\Users\matth> py
Python 3.8.3 (tags/v3.8.3:6f8c832, May 13 2020, 22:37:02) [MSC v.1924 64 bit (AMD64)] on win32
Type "help", "copyright", "credits" or "license" for more information.
>>>
```

To exit Python, simply type quit() and press enter.

```
Windows PowerShell
PS C:\Users\matth> py
Python 3.8.3 (tags/v3.8.3:6f8c8
Type "help", "copyright", "cred
>>> quit()
PS C:\Users\matth>
```

Installing & updating packages in Python

- Next, let us install **packages**. (**Packages:** extra functionalities for Python.)

Windows PowerShell

```
PS C:\Users\matth> py -m pip install numpy notebook
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py –m pip install numpy notebook

Windows PowerShell

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Note: if you are using **py3, python or python3** instead of **py**, adjust accordingly!

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- Next, let us install **packages**. (**Packages:** extra functionalities for Python.)
- To do so, run the following command in your console.

py –m pip install numpy notebook

Note: if you are using **py3, python or python3** instead of **py**, adjust accordingly!

Windows PowerShell

```
PS C:\Users\matth> py -m pip install numpy notebook
```

It shall run for a while, download and install a few things…
(numpy for advanced math computation and notebook, which we will use later on)

Windows PowerShell

```
  Running setup.py install for prometheus-client ... done
Successfully installed MarkupSafe-1.1.1 Send2Trash-1.5.0 attrs-19.3.0 backcall-0.1.0 bleach-3.d
11.2 jsonschema-3.2.0 jupyter-client-6.1.3 jupyter-core-4.6.3 mistune-0.8.4 nbconvert-5.6.1 nb
t-3.0.5 pygments-2.6.1 pyparsing-2.4.7 pyrsistent-0.16.0 python-dateutil-2.8.1 pywin32-227 pyw4
WARNING: You are using pip version 19.2.3, however version 20.1.1 is available.
You should consider upgrading via the 'python -m pip install --upgrade pip' command.          3
PS C:\Users\matth>
                                                                                                5
```

Our first program!

- Start python in a console, type **print(“Hello World!”)**, and submit by pressing Enter.
  It should display “Hello World!”.

Windows PowerShell

```
PS C:\Users\matth> py
Python 3.8.3 (tags/v3.8.3:6f8c832, May
Type "help", "copyright", "credits" or
>>> print("Hello World!")
Hello World!
>>>
```

Our first program!

- Start python in a console, type **print(“Hello World!”)**, and submit by pressing Enter.
  It should display “Hello World!”.
- **Definition (the “Hello World” program):** The **“Hello World” program** is a computer program that outputs or displays the message "Hello World!". It is often used as a **sanity test** to make sure that a computer language is correctly installed.

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Hello World!
>>>
```

When your code outputs "Hello World!"

Our first program!

- Assigning something to memory is done with the = sign.

Windows PowerShell

```
PS C:\Users\matth> py
Python 3.8.3 (tags/v3.8.3:6f8
Type "help", "copyright", "cr
>>> print("Hello World!")
Hello World!
>>> x = 10 + 3
>>> print(x)
13
>>>
```

Our first program!

- Assigning something to memory is done with the $=$ sign.
- **Note:** The $=$ sign does not bear the same meaning as seen in mathematics.

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```

Our first program!

- Assigning something to memory is done with the $=$ sign.
- **Note:** The $=$ sign does not bear the same meaning as seen in mathematics.
- In computer science it means:
  - Assign what is on the right-hand side of the equal sign to memory.
  - The name of this element, called a **variable**, consists of the text on the left-hand side of the equal sign.

Windows PowerShell

```
PS C:\Users\matth> py
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Type "help", "copyright", "cr
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Our first program!

- Here, we have assigned the numerical value resulting from the operation $\mathbf{10 + 3}$, to a **variable** named **x**.

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Our first program!

- Here, we have assigned the numerical value resulting from the operation $\mathbf{10 + 3}$, to a **variable** named **x**.

- Later on, we can retrieve the value stored in the variable, and – for instance – ask the computer to print it on screen for us, with the **print()** function.

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>>>
```

Outputs nothing! Need to explicitly ask for a print().

Matt’s Great advice #1

Matt’s Great Advice #1: the print() function in Python.

The **print()** function is the most important Python function.

It is **only way** for you to check what is being computed and stored in memory at any given time.

Use it and abuse it, to check what your program is doing!

Executing a .py file in console mode

- You should have downloaded a few files along with the lecture notes on eDimension.
- More specifically, we will now use the **first_program.py** file.

Executing a .py file in console mode

- You should have downloaded a few files along with the lecture notes on eDimension.
- More specifically, we will now use the **first_program.py** file.
- Identify where your **first_program.py** file is currently located, before moving to the next slide.

Executing a .py file in console mode

- **Command (dir/ls):** The **dir command** (or **ls command** in Mac OS/Linux) lists the folders and files in your current location.

Current location is C:\Users\matth\

Windows PowerShell

```
PS C:\Users\matth> dir


    Directory: C:\Users\matth


Mode                LastWriteTime         Length Name
----                -------------         ------ ----
d-----        07-Aug-19     17:31                .anaconda
d-----        07-Aug-19     17:31                .astropy
d-----        08-May-20     02:43                .cache
d-----        07-Aug-19     17:35                .conda
d-----        07-Aug-19     17:31                .config
d-----        10-Aug-18     15:14                .ipython
d-----        07-Feb-19     18:03                .jupyter
d-----        19-Aug-19     20:17                .keras
d-----        14-Mar-19     14:24                .kivy
d-----        11-Nov-19     10:13                .matplotlib
d-----        08-Aug-18     21:17                .Origin
d-----        08-Aug-18     21:17                .QtWebEngineProcess
d-----        07-Aug-19     17:31                .spyder-py3
d-r---        13-May-20     21:02                3D Objects
d-----        26-Mar-19     21:41                ansel
```

Executing a .py file in console mode

- **Command (dir/ls):** The **dir command** (or **ls command** in Mac OS/Linux) lists the folders and files in your current location.
- **Command (cd):** The **cd command** changes your current location to another folder, reachable from your current location in **dir/ls**.

Observe how the current location is changing every time.

Select Windows PowerShell

```
PS C:\Users\matth> cd Desktop
PS C:\Users\matth\Desktop> cd ..
PS C:\Users\matth> cd Downloads
PS C:\Users\matth\Downloads>
```

Executing a .py file in console mode

- **Command (dir/ls):** The **dir command** (or **ls command** in Mac OS/Linux) lists the folders and files in your current location.
- **Command (cd):** The **cd command** changes your current location to another folder, reachable from your current location in **dir/ls**.
- **Note:** the command "**cd ..**" moves you back one level.

Observe how the current location is changing every time.

Select Windows PowerShell

```
PS C:\Users\matth> cd Desktop
PS C:\Users\matth\Desktop> cd ..
PS C:\Users\matth> cd Downloads
PS C:\Users\matth\Downloads>
```

Windows PowerShell

```
PS C:\Users\matth> cd Desktop
PS C:\Users\matth\Desktop> cd ILP
PS C:\Users\matth\Desktop\ILP> cd '.\2. Teaching materials (ILP 2020)\'
PS C:\Users\matth\Desktop\ILP\2. Teaching materials (ILP 2020)> cd .\W1S1\
PS C:\Users\matth\Desktop\ILP\2. Teaching materials (ILP 2020)\W1S1> cd '.\Code files\'
PS C:\Users\matth\Desktop\ILP\2. Teaching materials (ILP 2020)\W1S1\Code files> dir


    Directory: C:\Users\matth\Desktop\ILP\2. Teaching materials (ILP 2020)\W1S1\Code files

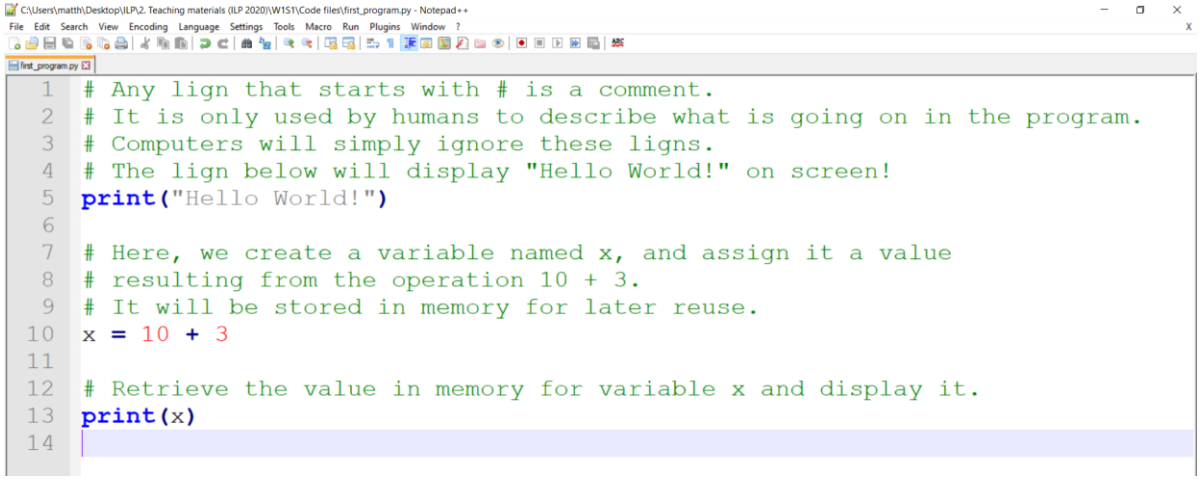

Mode                LastWriteTime         Length Name
----                -------------         ------ ----
d-----        19-May-20     20:09                .ipynb_checkpoints
-a----        19-May-20     21:40            469 first_program.py
-a----        19-May-20     21:40           1810 Our first notebook.ipynb
-a----        19-May-20     21:06           3205 Our second notebook.ipynb


PS C:\Users\matth\Desktop\ILP\2. Teaching materials (ILP 2020)\W1S1\Code files>
```

→ Now, using cd/dir/ls move to the location of your **first_program.py** file !

Checking your .py file

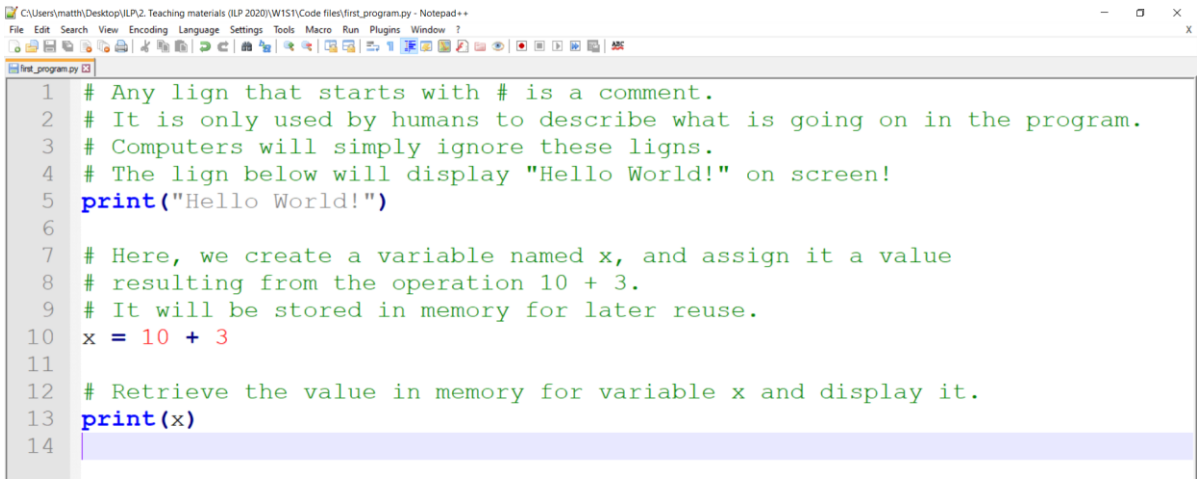
- Open your **first_program.py** file with any text editor (specifically do it by right clicking and asking to open with a text editor).
- Recognize the code we used earlier.

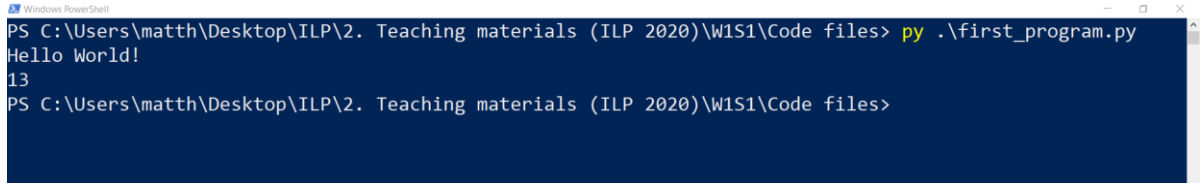


Checking your .py file

- Open your **first_program.py** file with any text editor (specifically do it by right clicking and asking to open with a text editor).
- Recognize the code we used earlier.
- Later on, you can run the code in the **first_program.py** file, all at once, by typing the following command in your console

py first_program.py





Running Python from an IDE

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- **Problem:** Typing code in a text editor and running it from console is not exactly convenient…
- **Suggestion:** we should use an **Interactive Development Environment (IDE)**, which makes the coding easier for us.
- In this course, I suggest to use **Jupyter Notebook**, but you might look online for other IDEs if you want!

Running Python from an IDE, such as a Jupyter Notebook

- Return to your console, **outside** of the Python environment (use **quit()** if needed).

Running Python from an IDE, such as a Jupyter Notebook

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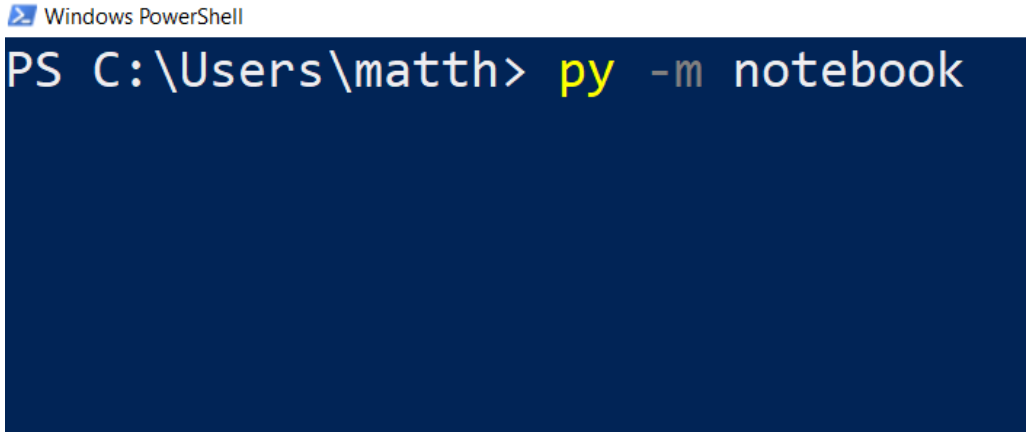
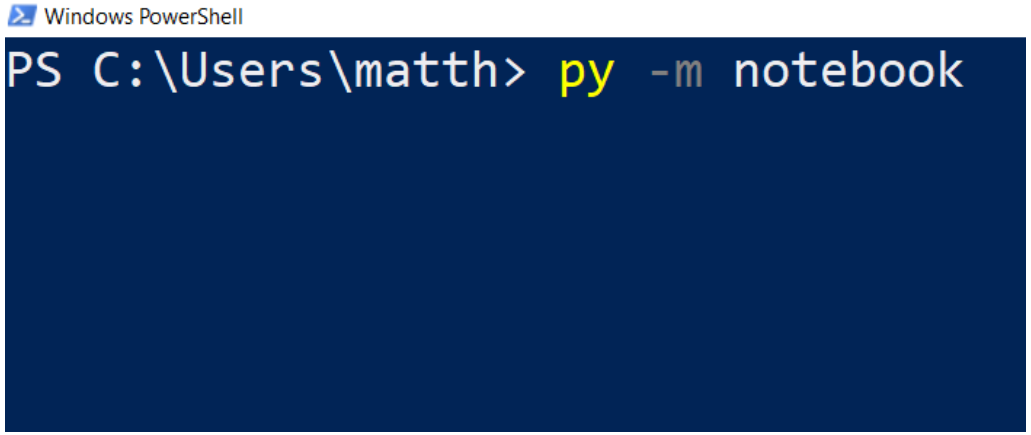
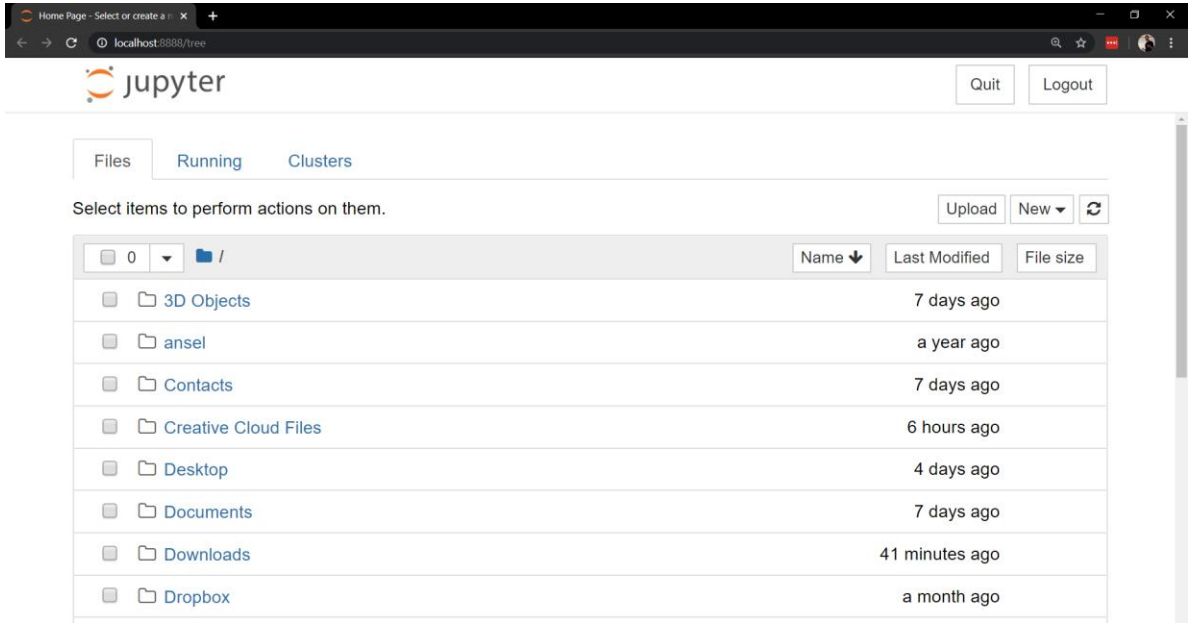
- Type **py –m notebook**, and press enter to submit and call the **Python notebook module** (-m notebook)



Running Python from an IDE, such as a Jupyter Notebook

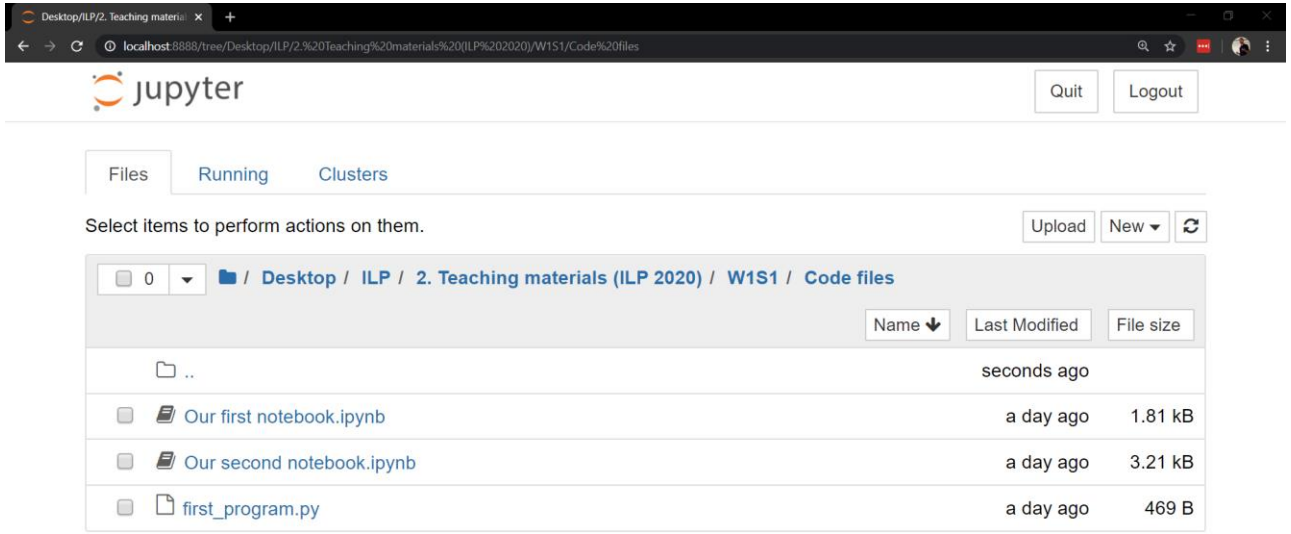
- Return to your console, **outside** of the Python environment (use **quit()** if needed).
- Type **py –m notebook**, and press enter to submit and call the **Python notebook module** (-m notebook)
- **It should open a notebook window/tab in your web browser.**





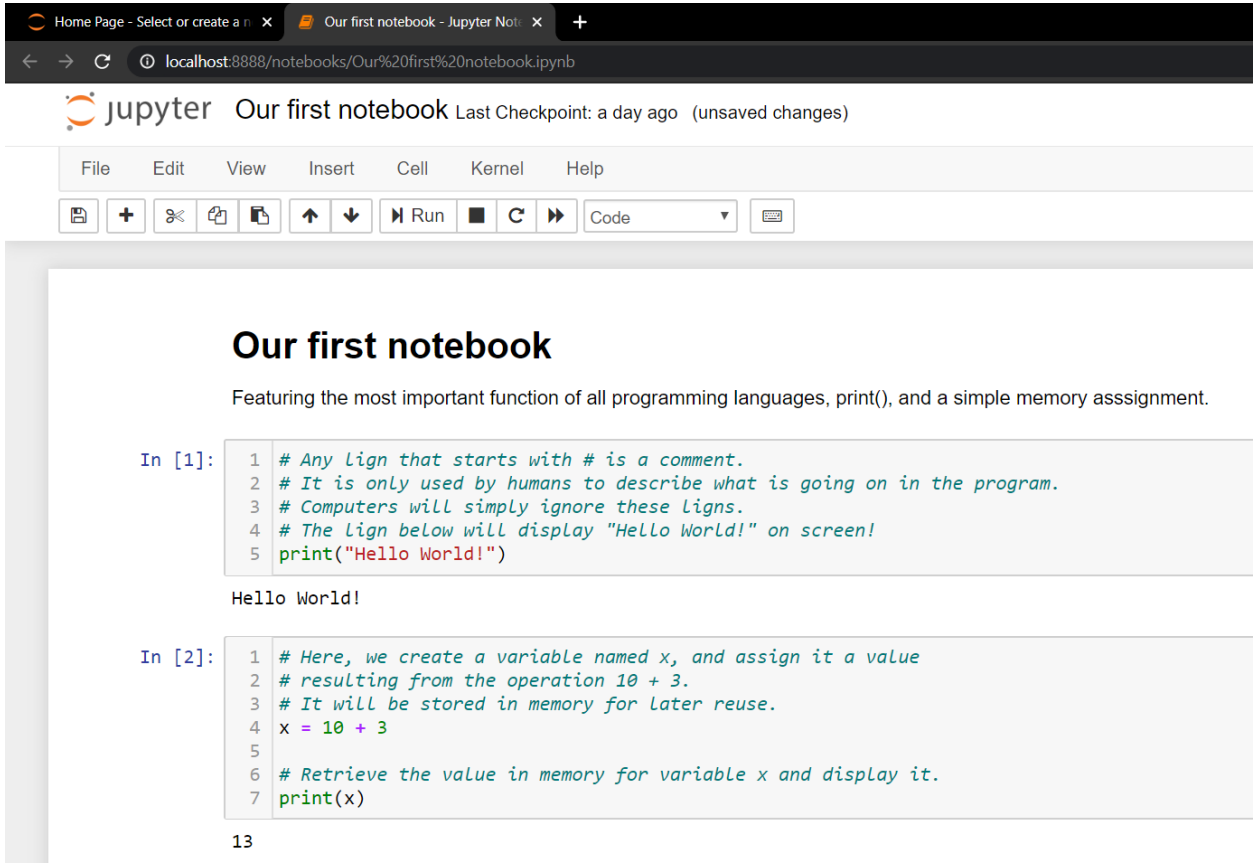
Running Python from an IDE, such as a Jupyter Notebook

- Notebooks are a more convenient way to program on Python.
- They provide an explorer to navigate to a folder of your choice.
- Move to the folder where the code you downloaded is.



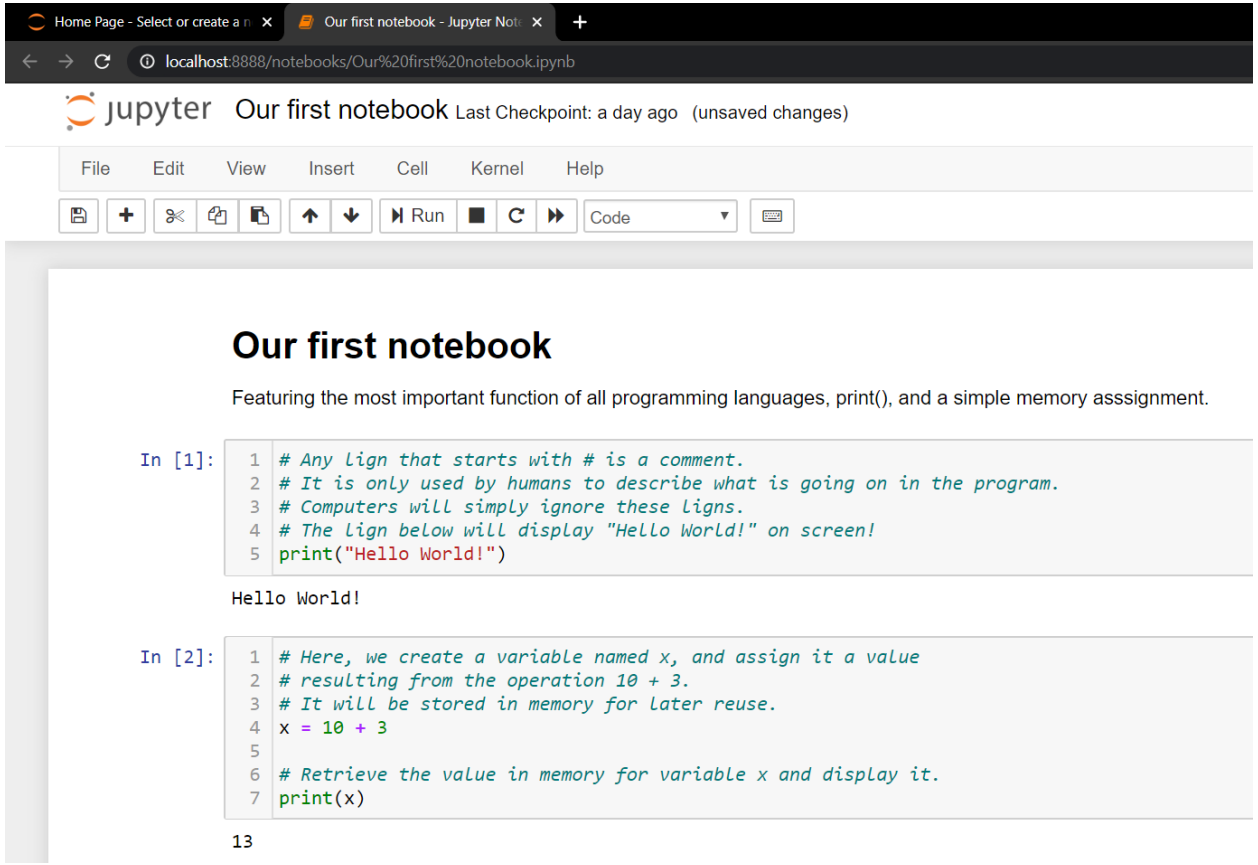
Running Python from an IDE, such as a Jupyter Notebook

- Notebooks provide a mixed combination of
  - **text blocks** (in Markdown language)
  - and **code blocks** (in Python, these blocks have a “In [ ]” on their left side).



Running Python from an IDE, such as a Jupyter Notebook

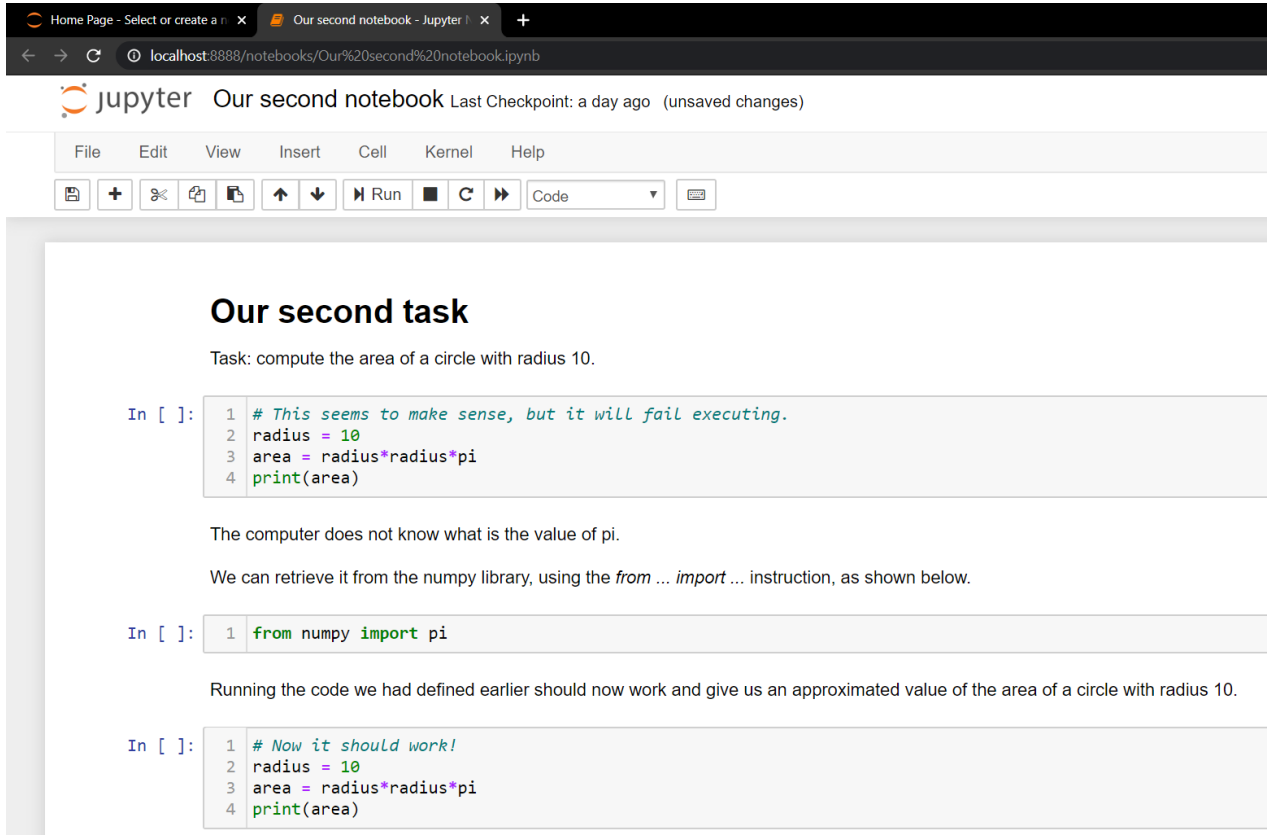
- Notebooks provide a mixed combination of
  - **text blocks** (in Markdown language)
  - and **code blocks** (in Python, these blocks have a “In [ ]” on their left side).
- Try executing a cell of code by selecting it and pressing **Shift+Enter**!
- A lot more convenient isn’t it?



Our second task

- Let us consider a **second task:** compute the area of a circle with radius 10.

- Open the second notebook.

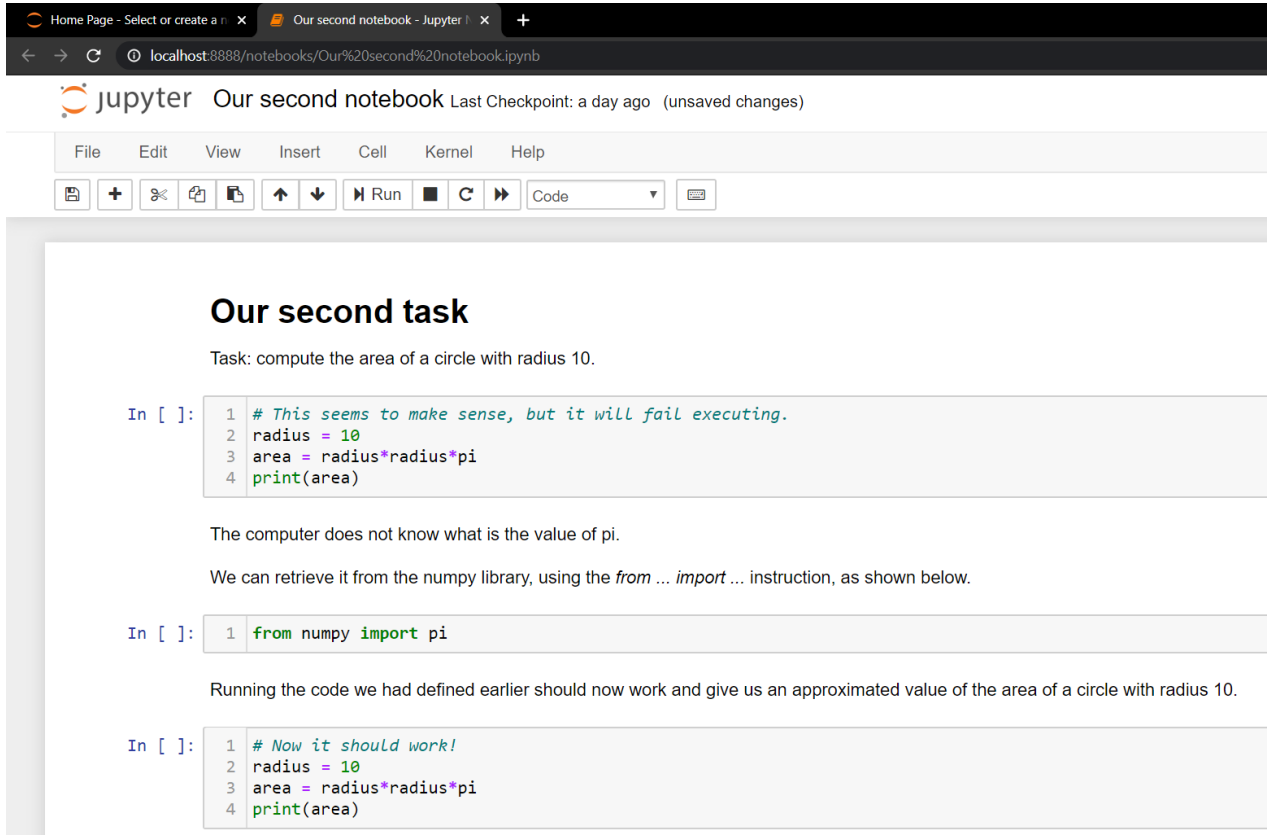


Our second task

- Let us consider a **second task:** compute the area of a circle with radius 10.

- Open the second notebook.

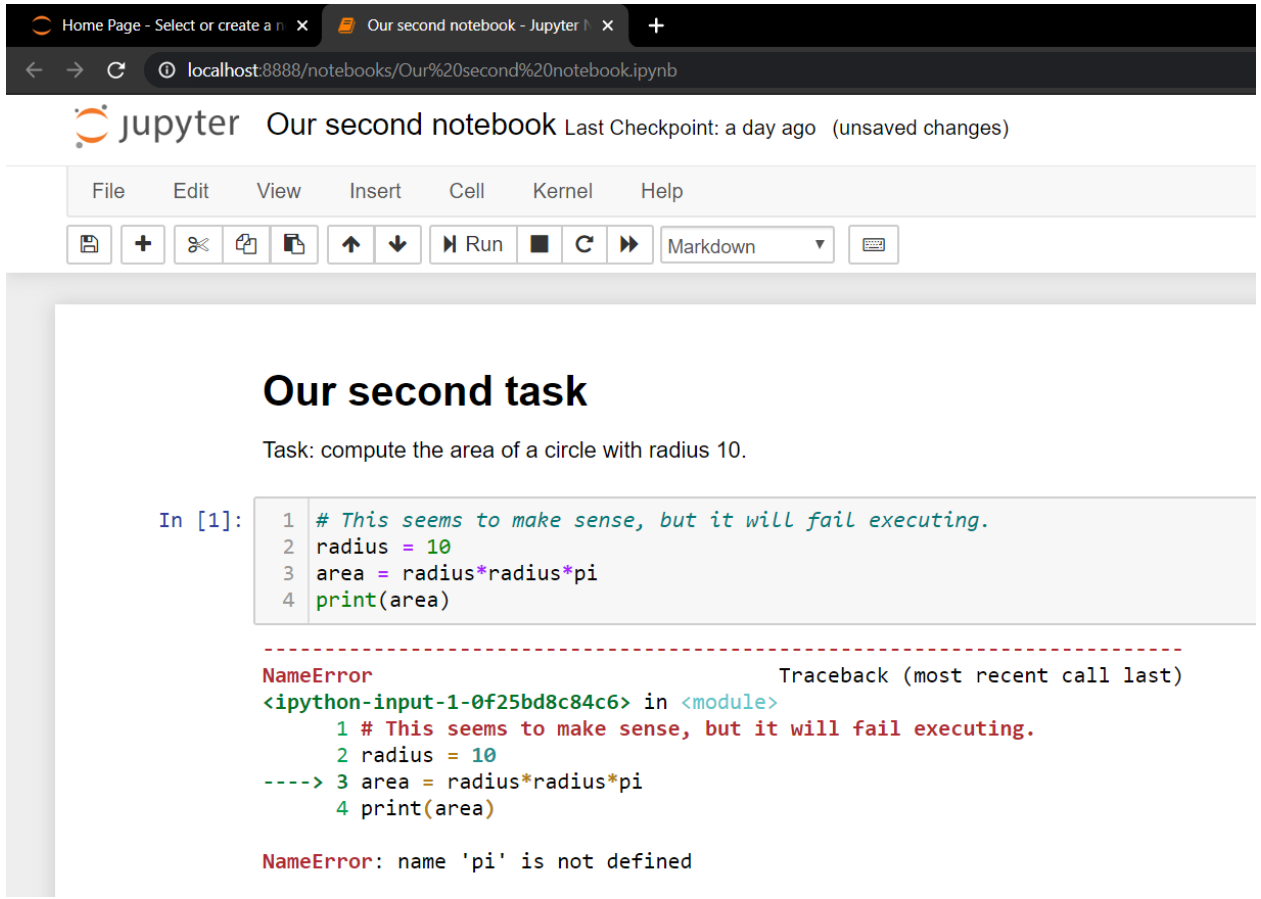
- **Note:** in computer science, the multiplication operation is denoted $*$, not $\times$.



Our second task: problem

- While the task seems easy mathematically speaking, we have a problem…

  → **We need the value of pi.**



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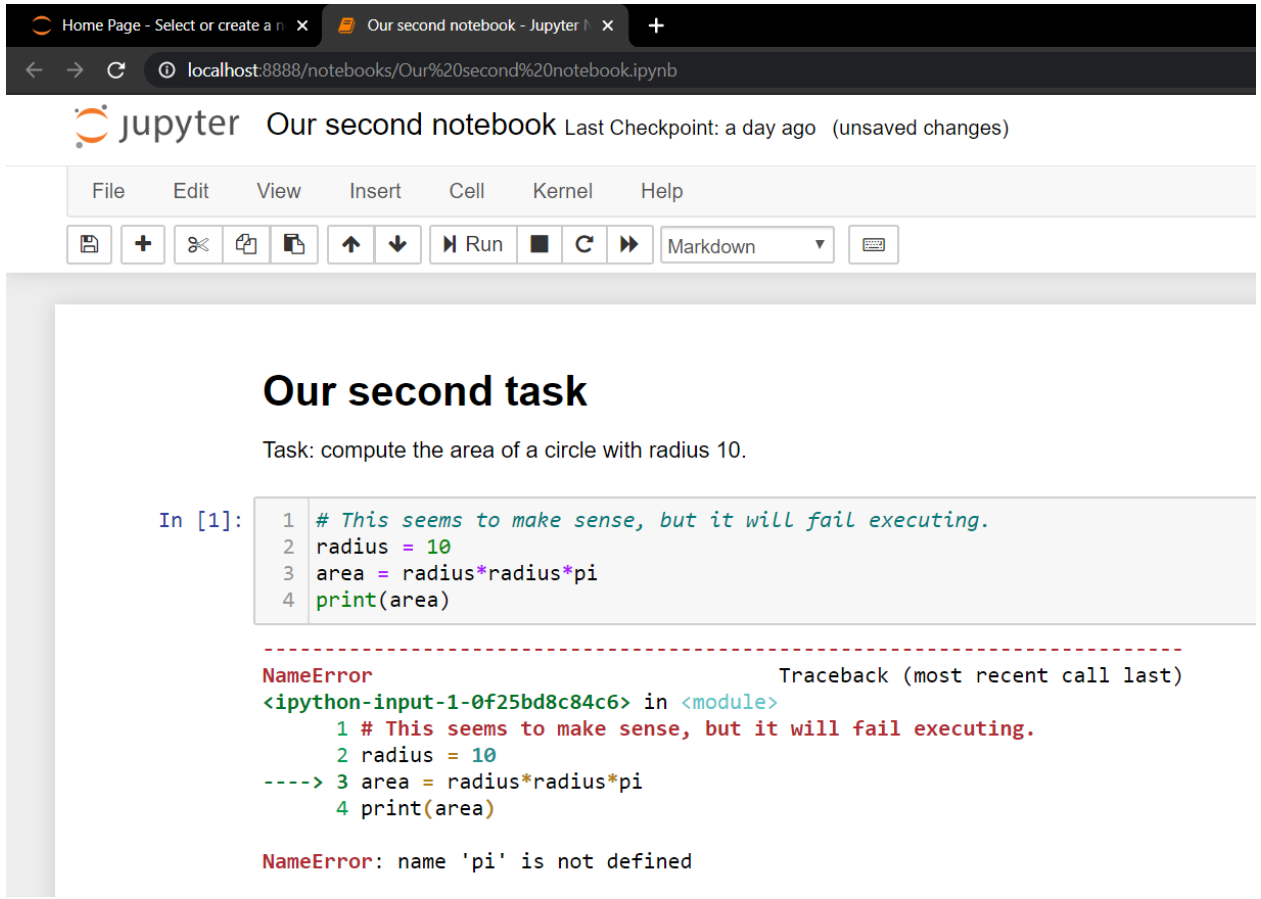
  → **We need the value of pi.**

- We could type 3.14, but it is better to retrieve it from a **package**.



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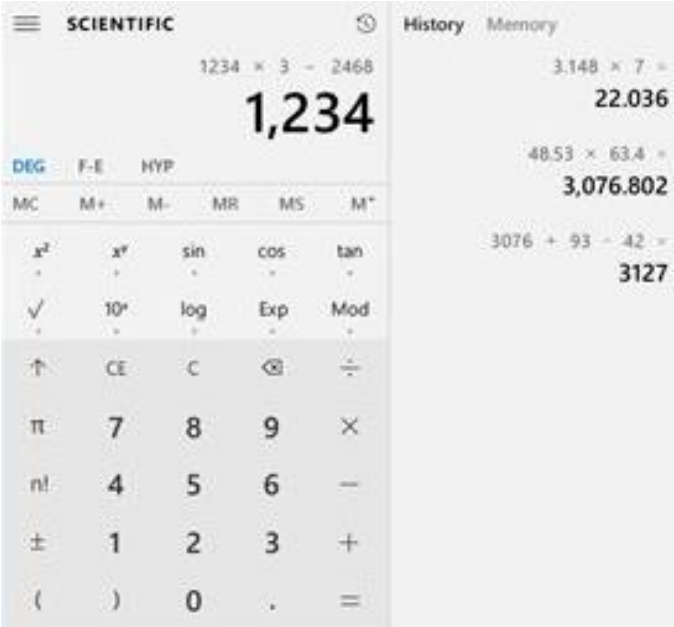
- **Import** ≈ adding a specific button to your calculator.



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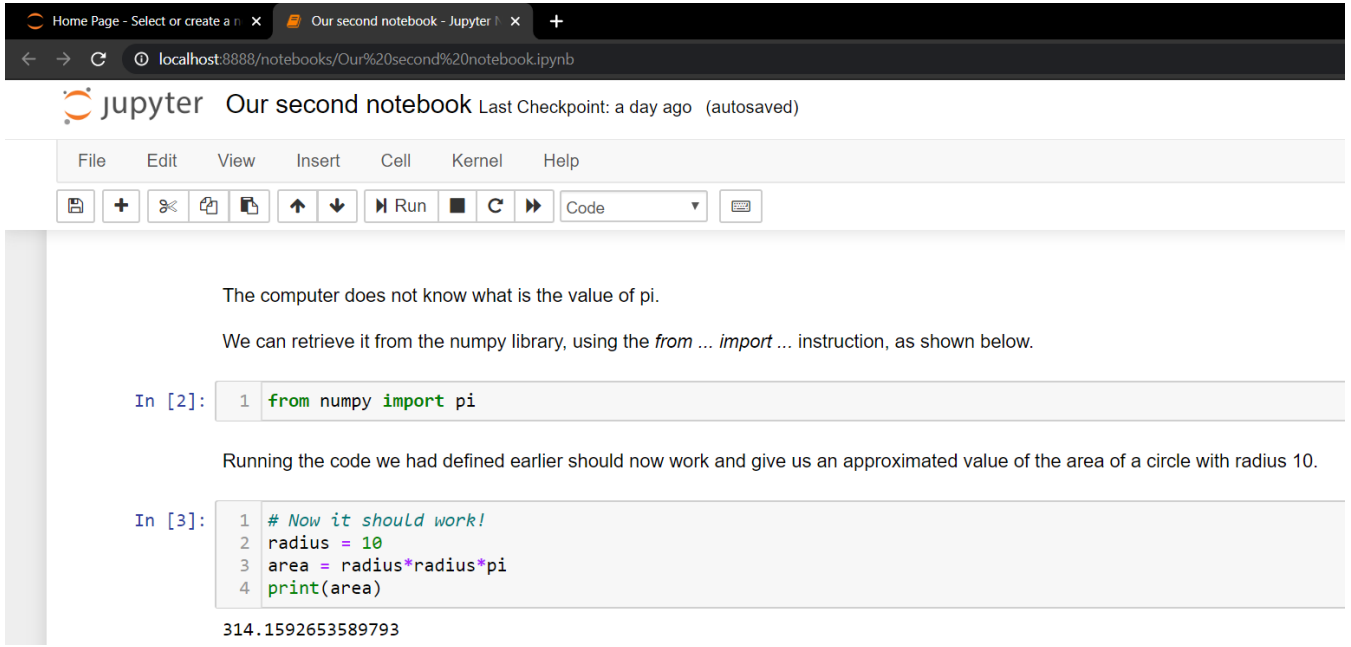

Congrats, you now have a Python-compatible machine, ready to run!

Feel free to play around a bit more if you want!

Conclusion

What we have seen

- What is programming?
- Programming Languages and why we will use Python.
- Installing Python, extra packages and IDEs.
- Test run to confirm everything works.

→ If you were able to execute the two codes (in console and Jupyter Notebooks): you are officially done for today.

→ Let me know in Zoom chat if you have encountered technical issues and we will try to fix them together.