Programmering af Mobile Robotter

RB1-PMR – Module 2: Basic programming concepts using Python

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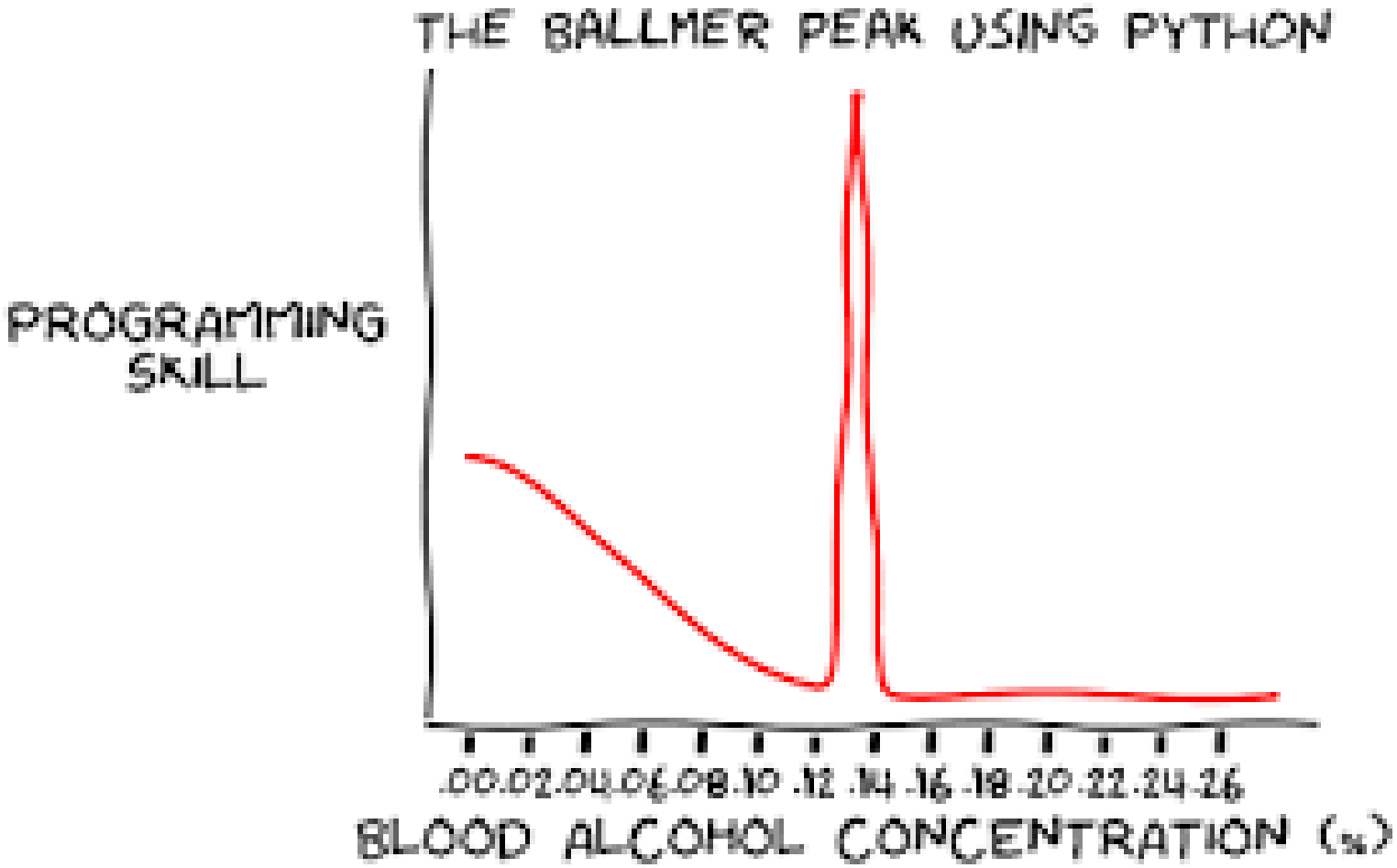
SDU Drone Center, MMMI, University of Southern Denmark, Odense, Denmark

Agenda

- Recap of last module
- Introduction to programming
- **Basic concepts in programming** (using Python)
  - Operators (Arithmetic, conditional, and Logical)
  - Built-in **data types** and **functions**
  - **Conditional statements** and **loops**
  - **Functions** and error handling
  - Troubleshooting and Debugging (basic)
- Extra Credit Activity 1: Calculator
- Assignments

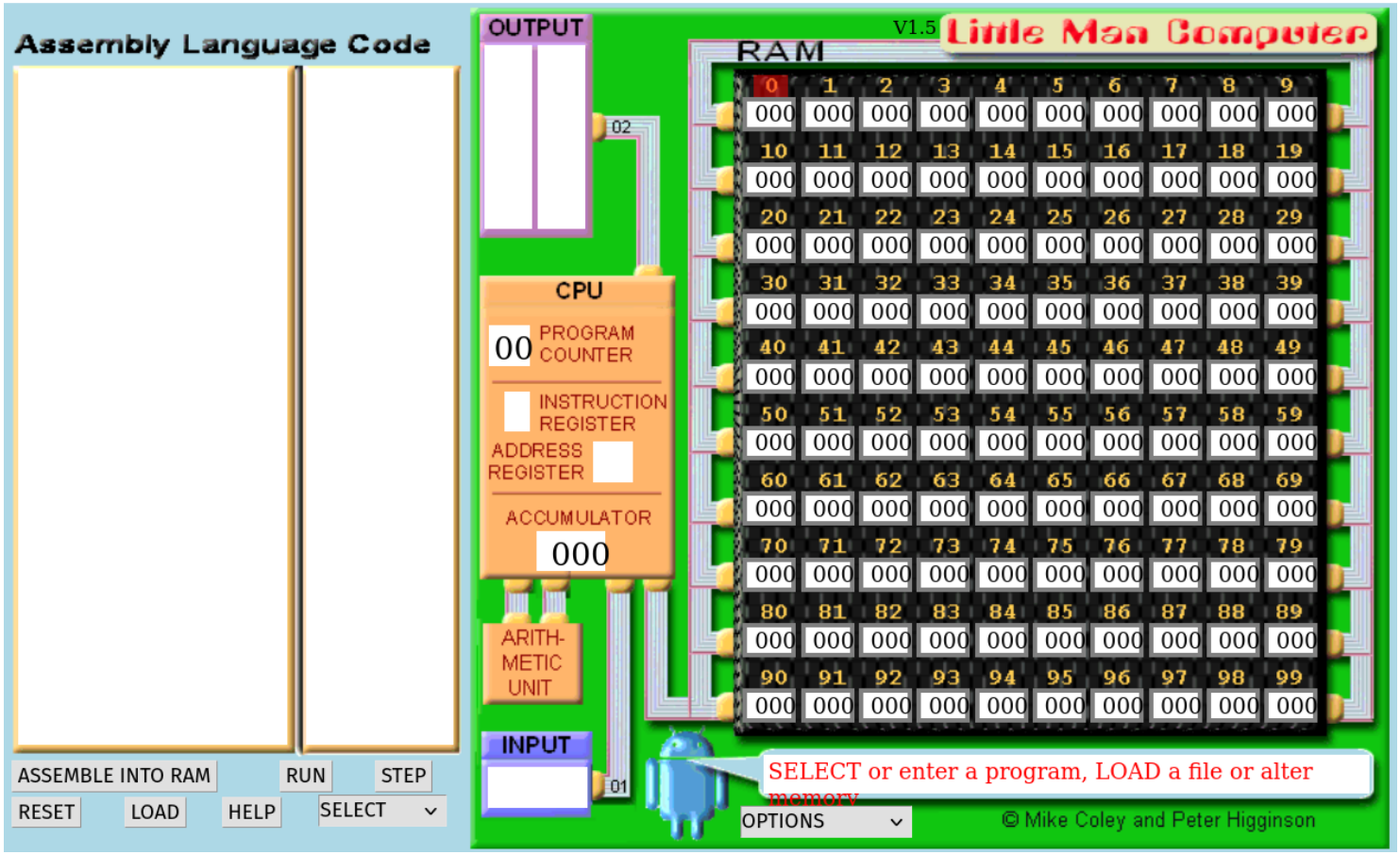
Recap (Friday)



Recap

- Introduction to the course and microcontrollers
- Number systems
  - Binary <-> Decimal <-> Hexadecimal
- **Micro-architecture**
  - Von Neumann and Harvard architecture
  - Key components
- **Little Man Computer** (assignment)
  - Fetch, decode, and execute cycle
  - (Solution will be available on ItsLearning)

  - **How was it?**



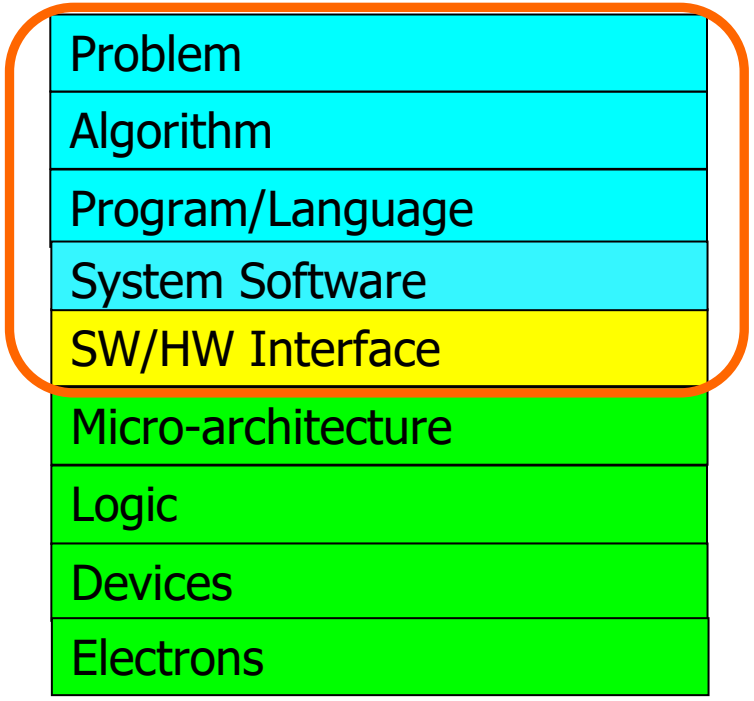
Programming

In-Class Q/A:
“What is programming?”

Programming (or **coding**)

- Definition[1]:

*"The composition of **sequences of instructions**, called programs, that computers can follow to **perform tasks**."*



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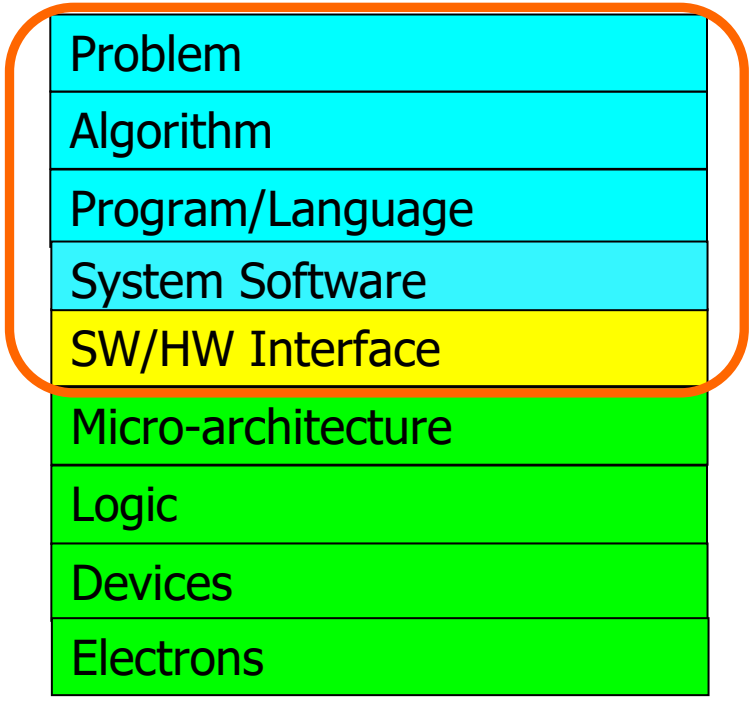

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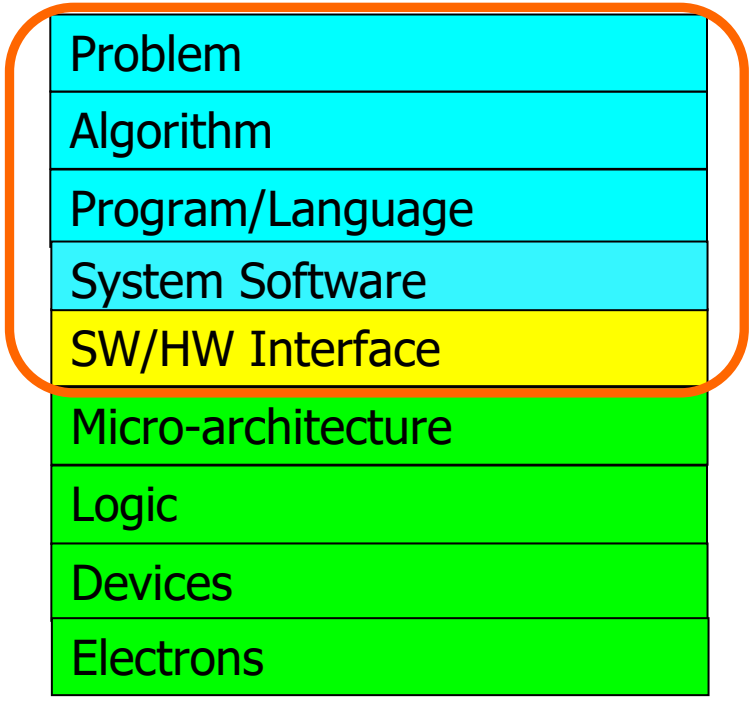
    1. **Problem Definition:** Understanding and defining the problem that needs to be solved.



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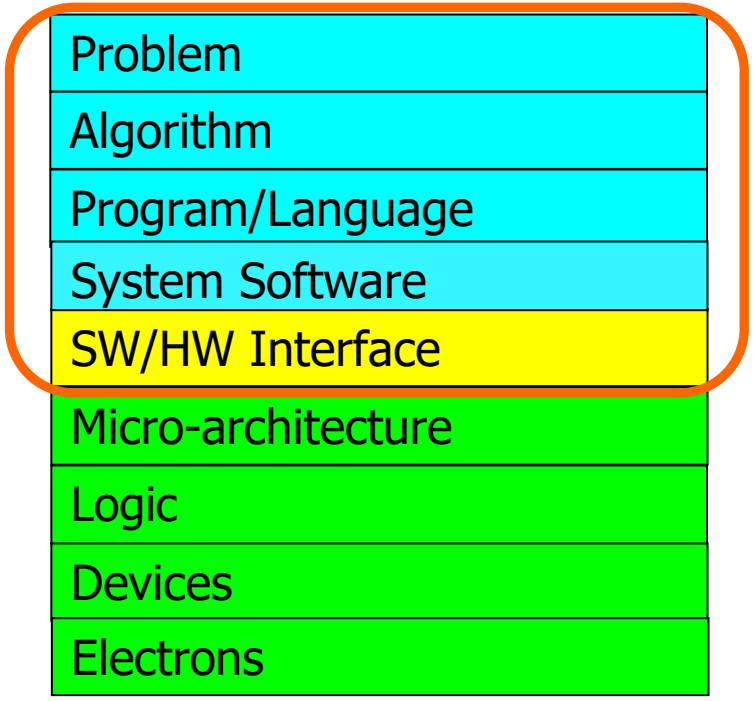
- Best practice involves:
  1. **Problem Definition:** Understanding and defining the problem that needs to be solved.
  2. **Algorithm Design:** Creating a step-by-step procedure or set of rules to solve the problem, eg. using
     a. **Pseudocode:** Express an algorithm or process in plain language, without the strict syntax of a programming language.
     b. **Diagrams:** Flowcharts, state diagrams, etc.



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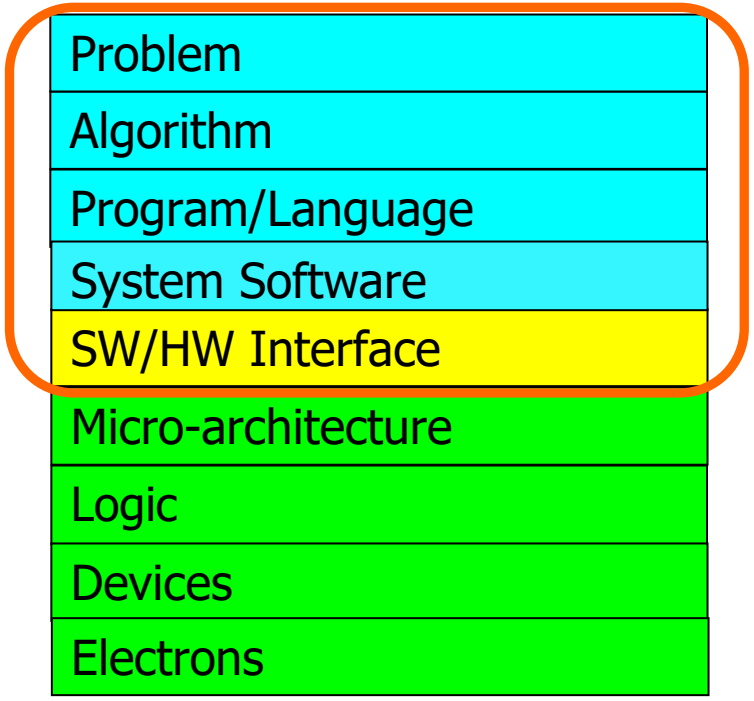
  3. **Programming:** Writing the algorithm in a programming language.



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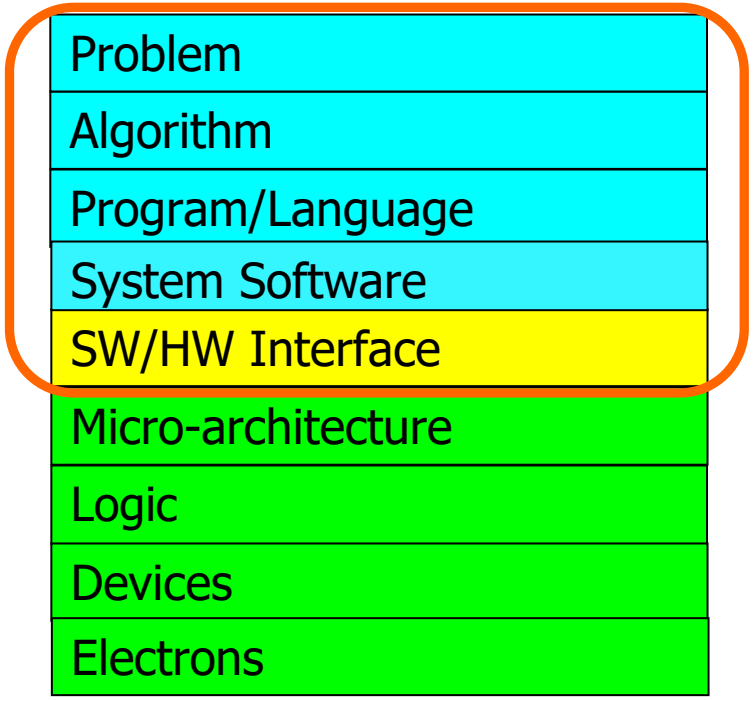

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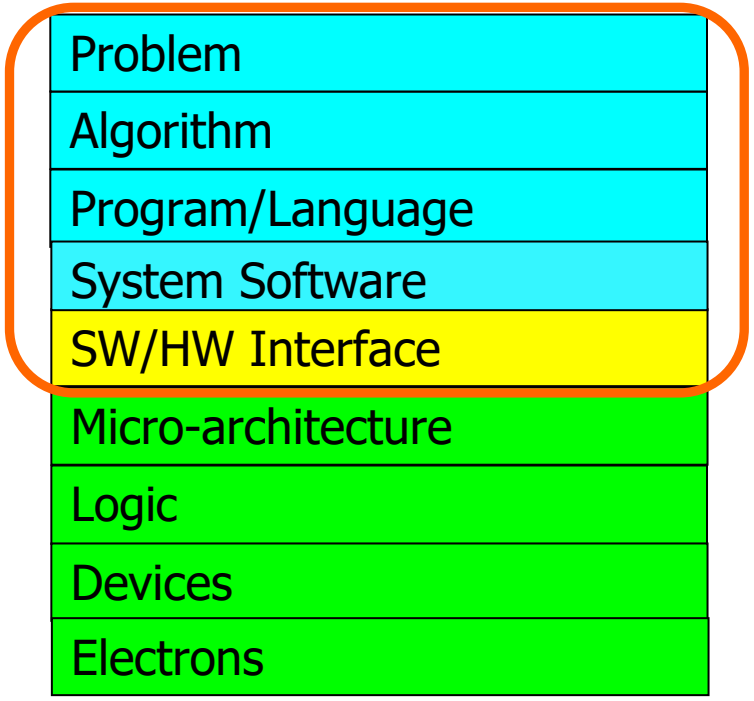

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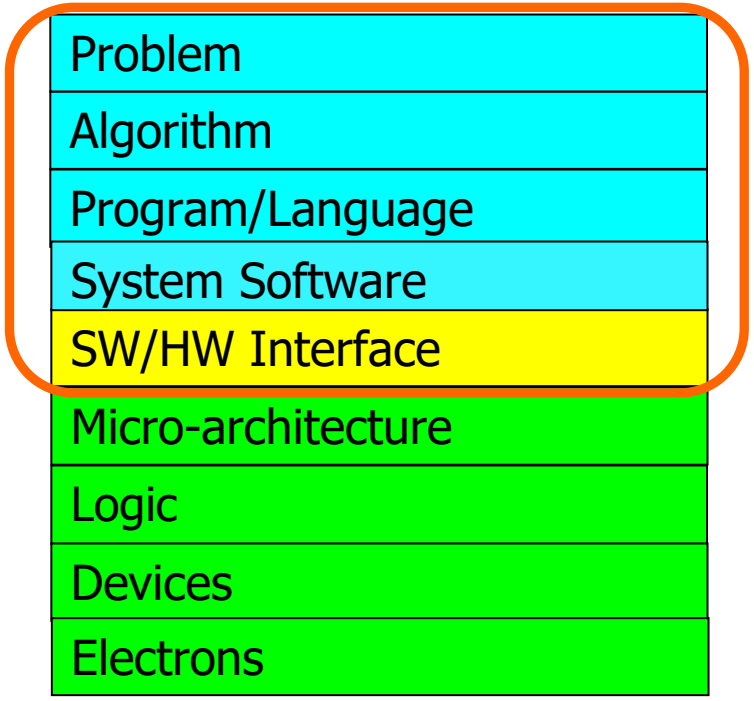

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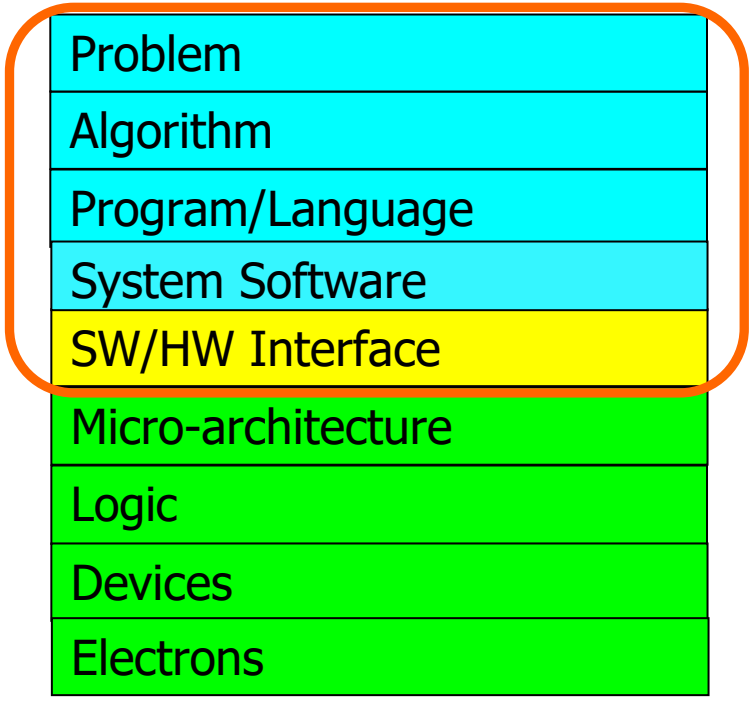
     a. Repeat the process… **(iterative process)**



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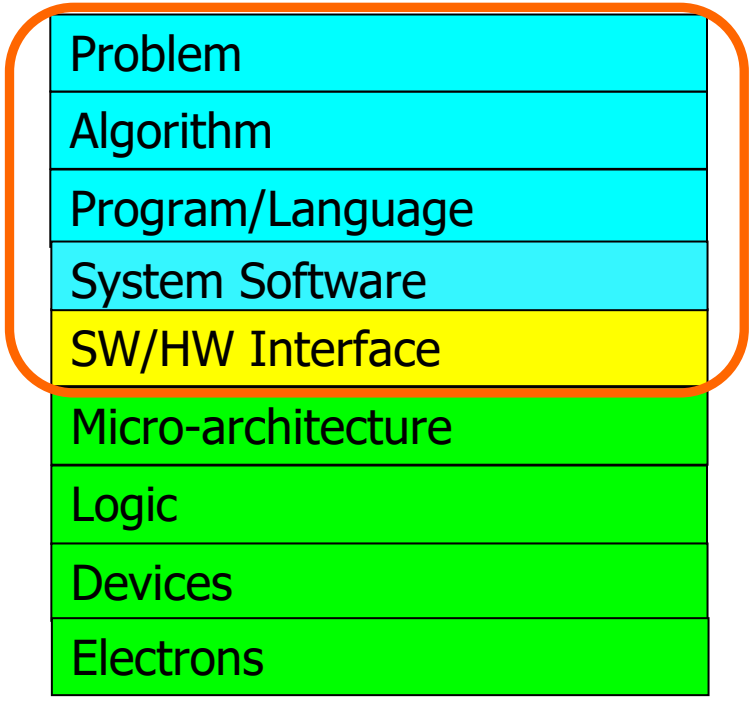
- (Best) Practice involves:
  1. **practice, practice, practice, etc.**
  2. **…and more practice…**



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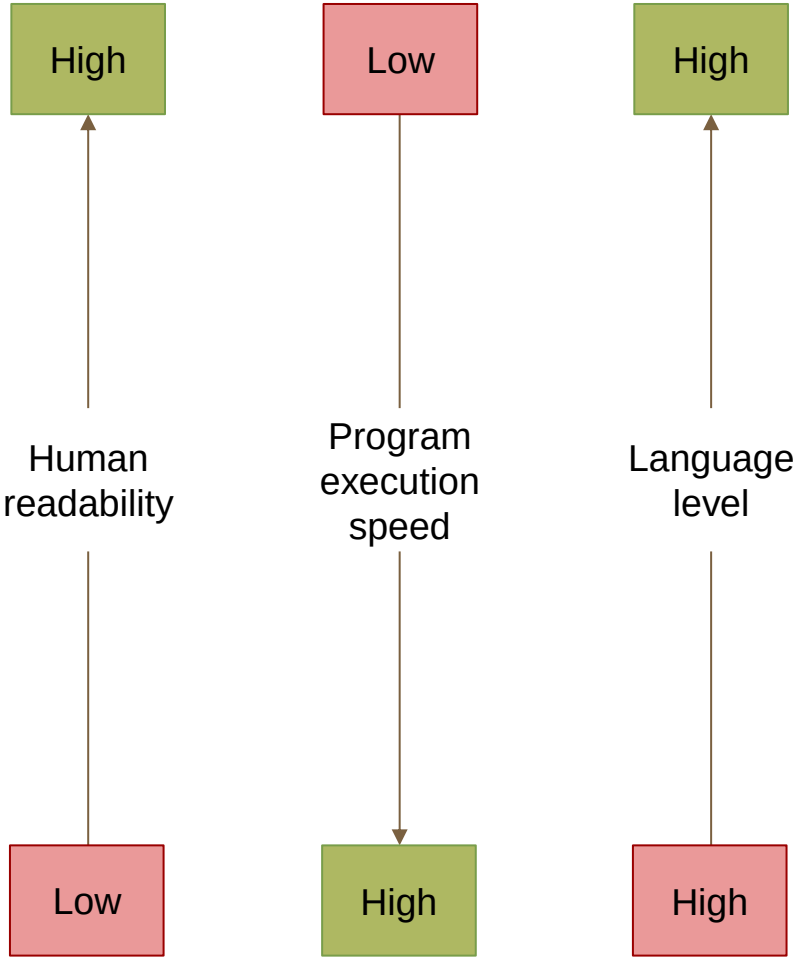
Levels of Programming

In-Class Q/A:
"What is your definition/understanding of high-level *and low-level programming?"*
Mid-level programming?

Levels of Programming languages

- **High-level**
  - Easy to read/write and learn
  - (Typically) Lower performance due to overhead
  - Limited control over hardware
  - Good for prototyping and quick development
  - Advanced tools (eg. error handling, data management)



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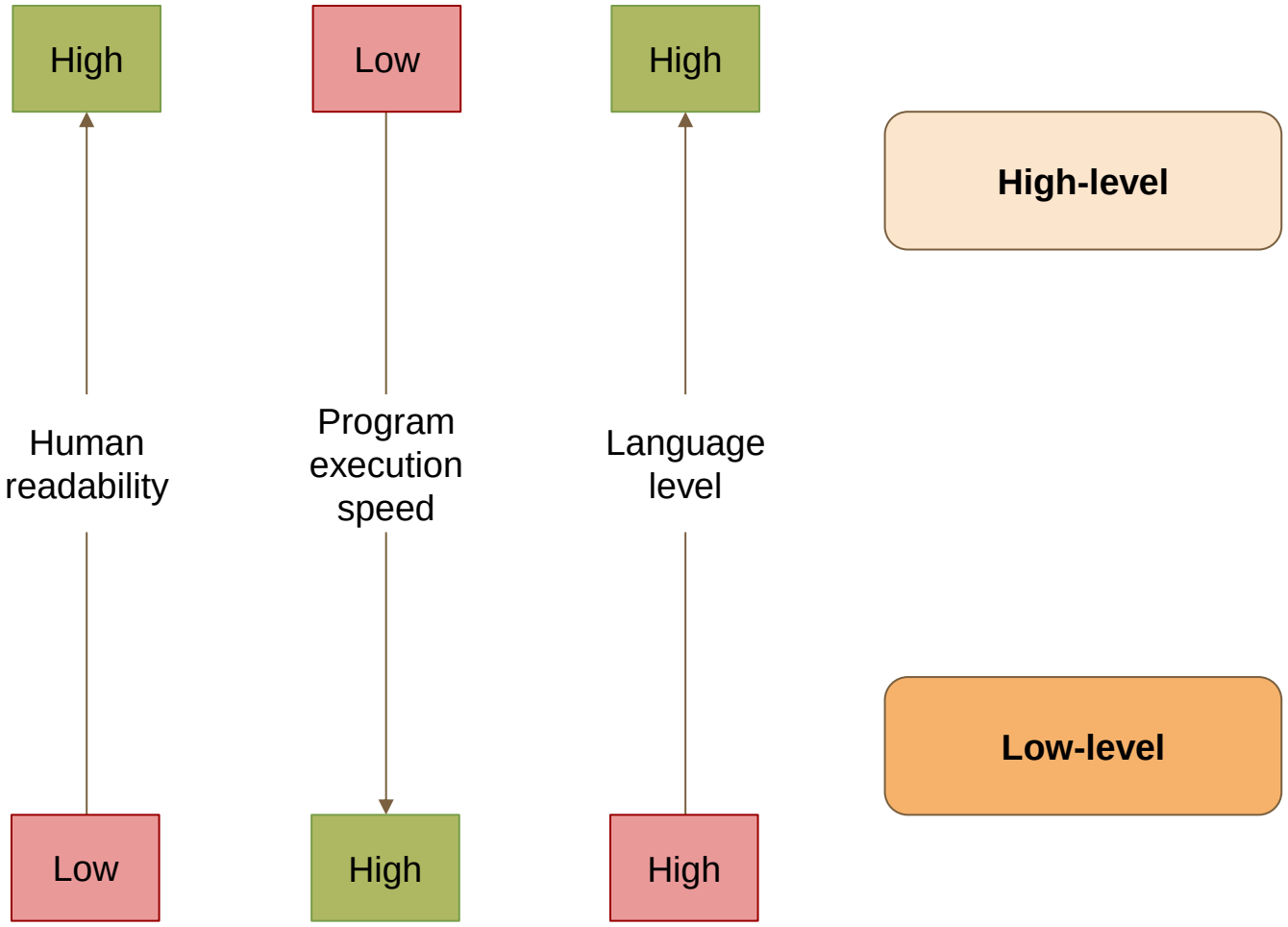
- **Low-level**
  - Difficult to read/write and learn
  - High performance due to direct control
  - Full control over hardware
  - Time-consuming to develop and maintain
  - Minimal error handling…



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  - Limited control over hardware
  - Good for prototyping and quick development
  - Advanced tools (eg. error handling, data management)

- **Mid-level**
  - A balance between high-level ease of use and low-level control over hardware

- **Low-level**
  - Difficult to read/write and learn
  - High performance due to direct control
  - Full control over hardware
  - Time-consuming to develop and maintain
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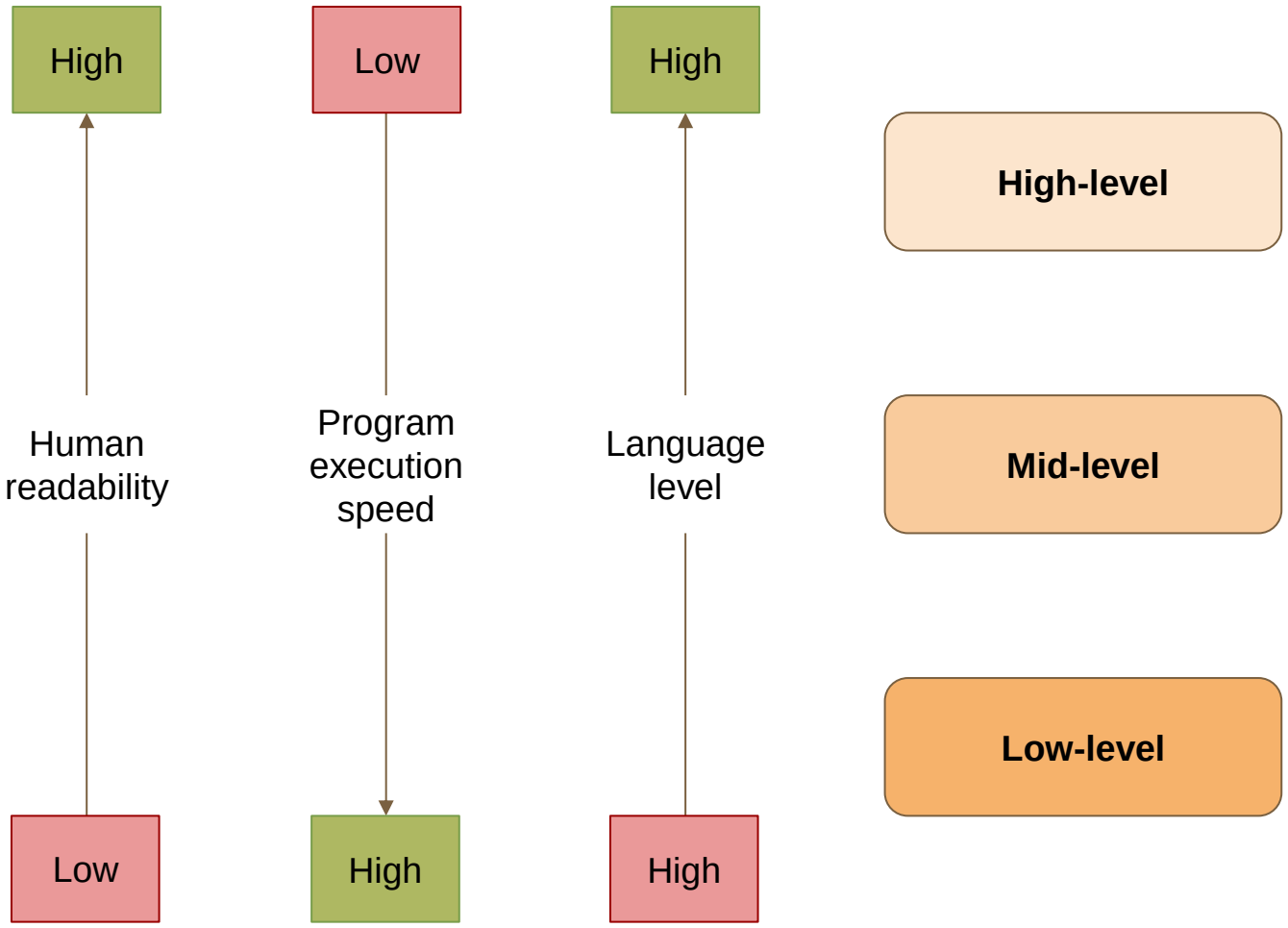
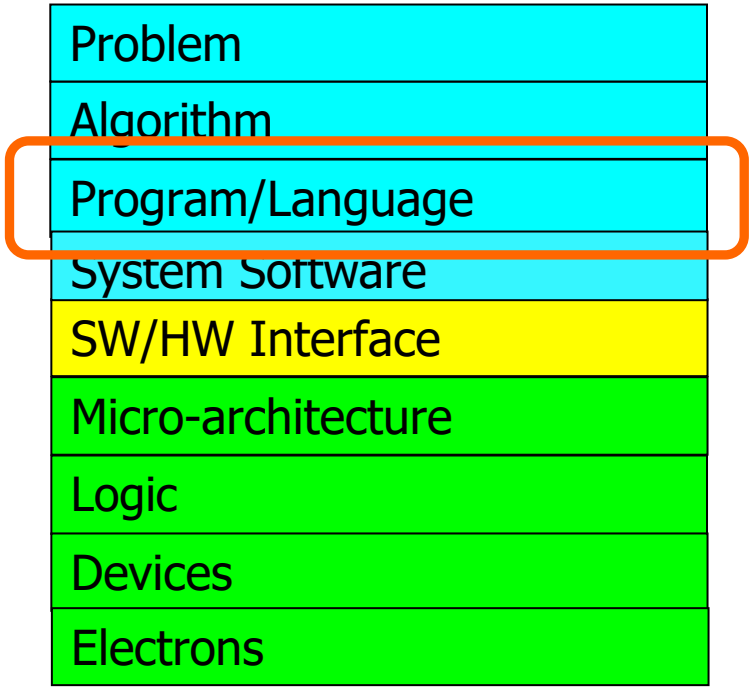


Levels of Programming languages

- **High-level**
  - JavaScript, Python, Ruby, etc.
- **Mid-level**
  - C, C++, Rust, etc.
- **Low-level**
  - Assembly Language, Machine code



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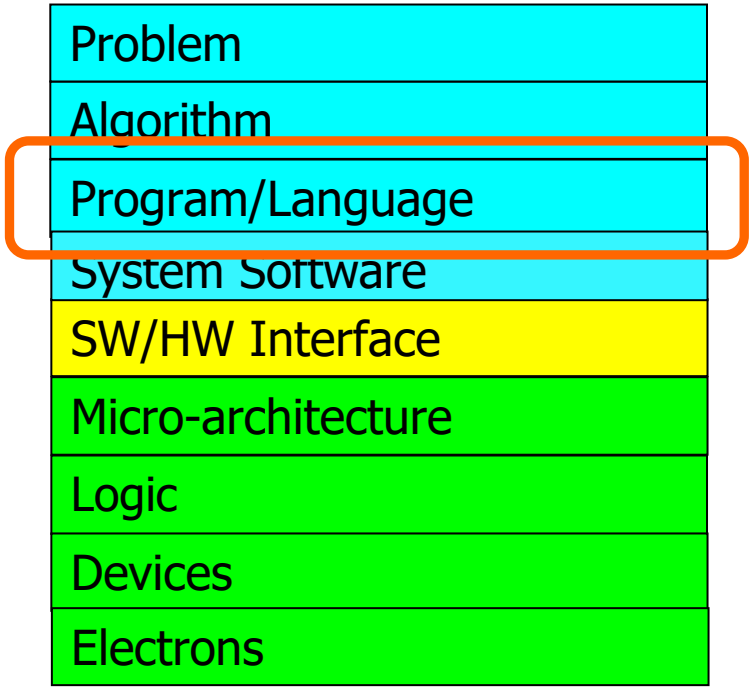
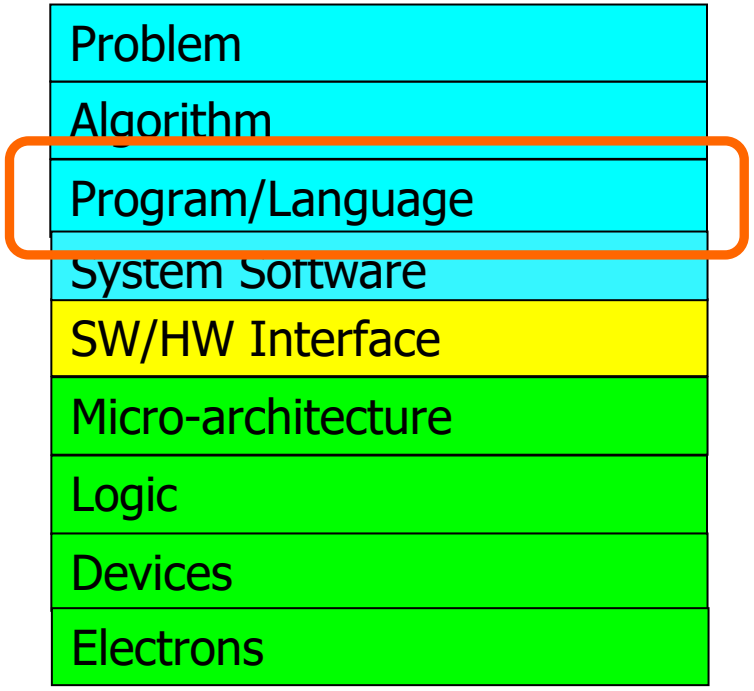


Definition changes over time?
Or from person-to-person?

Levels of Programming languages

- **High-level? Meta-level?**
  - CoPilot? ChatGBT?
- **Mid-level? High-level?**
  - JavaScript, Python, Ruby?
- **Low-level? Mid-level??**
  - C, C++, Rust?
- **VERY Low-level? Low-level?**
  - Assembly Language, Machine code?



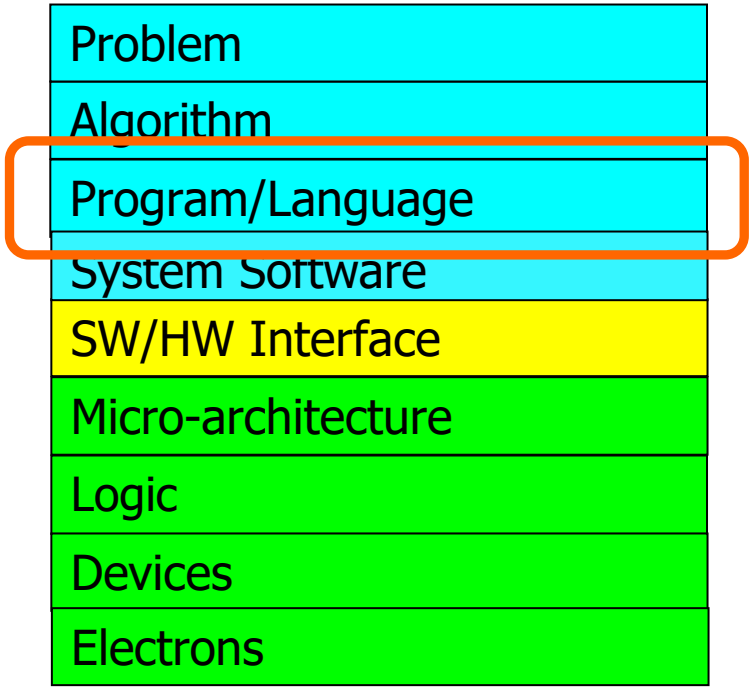
Definition changes over time?
Or from person-to-person?

Difference between programming languages?

Interpreted and **Compiled** languages?

- **Compiled Languages:** The code/program is translated from the source code into machine code (binary code) by a compiler before execution (executable file).

- **Interpreted Languages:** The code/program is executed line-by-line using an interpreter.



Interpreted and **Compiled** languages?

- **Compiled Languages:** The code/program is translated from the source code into machine code (binary code) by a compiler before execution (executable file).
  - = need to compile the entire program before running it.
    - Fast execution (the translation step is already done before run-time)
    - (Most) **Errors are detected** by the compiler before
      - Not runtime errors (eg. dividing by zero)
  - **Example languages:** C, C++, Rust, Java, etc.

- **Interpreted Languages:** Code is translated and executed line-by-line using an interpreter at runtime.

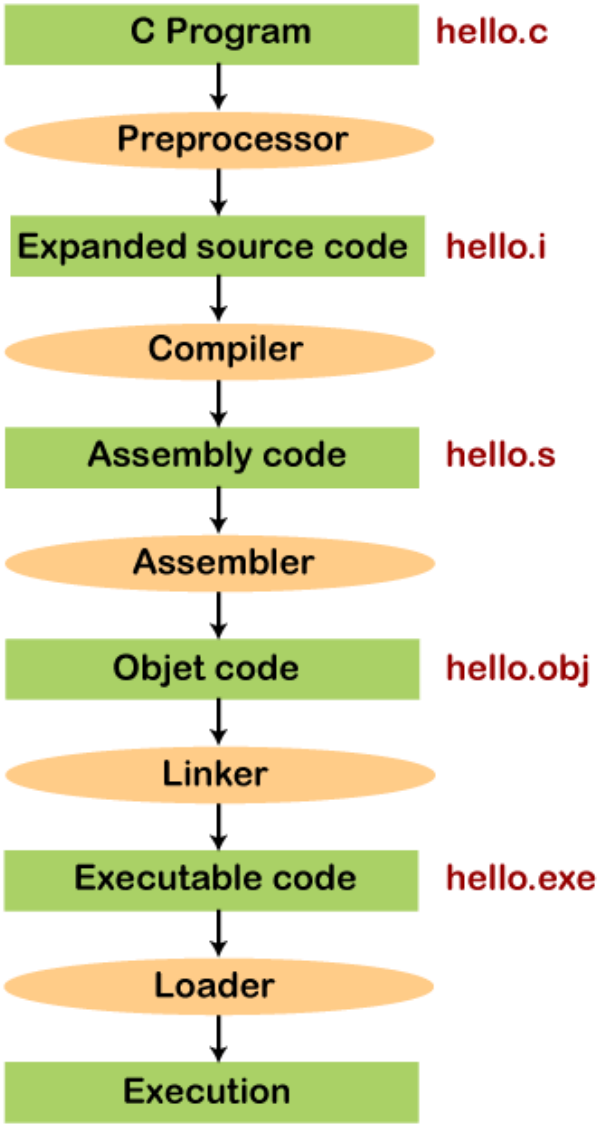
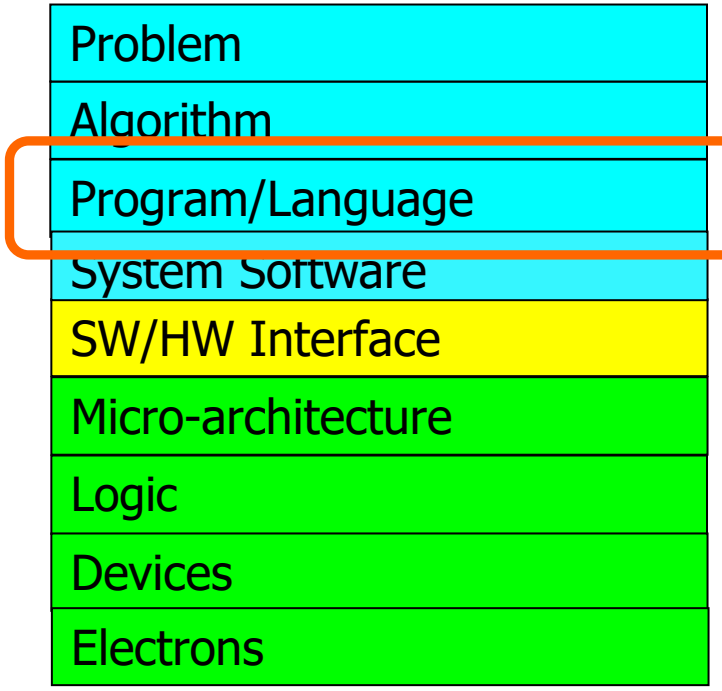


Illustration: https://medium.com/@elodieriou/the-compilation-process-in-c-b4325a4dd953

Interpreted and **Compiled** languages?

- **Compiled Languages:** The code/program is translated from the source code into machine code (binary code) by a compiler before execution (executable file).

- **Interpreted Languages:** Code is translated and executed line-by-line using an interpreter at runtime.
  - = no need to compile the entire program before running it
    - = fast prototyping!
    - ***"Move fast, break things"***
      - Errors are detected at runtime… **Good? Bad?**
  - Generally slower, since code is translated during execution
  - **Example languages:** Python, JavaScript, Ruby, etc.



Programming Language Syntax

*"...the **rules** that define the combinations of symbols that are considered to be correctly **structured statements or expressions** in that language."*

- **…so how you**
  - write commands,
  - declarations,
  - expressions,
  - structure of the source code,
  - etc.

Different programming language
=
Different syntax

Illustration: https://garbagevalue.com/definitions/syntax-programming-language

Programming Language Syntax (Examples)

Examples: Hello World		
High-level	Mid-level	Low-level
Python	**C++**	**Assembly**

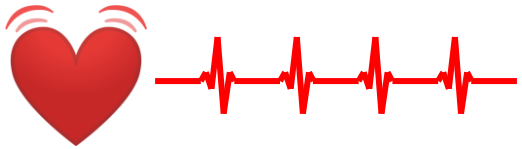
```python
print("Hello, World!") # Output string
```

```cpp
#include <iostream>

int main() {
    std::cout << "Hello, World!" << std::endl;   // Outp
    return 0;
}
```

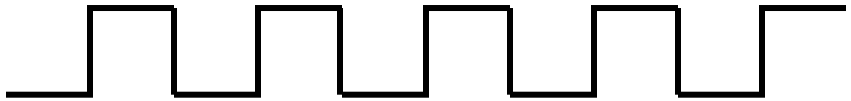
```assembly
section .data
    hello db 'Hello, World!', 0x0A  ; The string to be printed

section .text
    global _start

_start:
    ; Output string to stdout
    mov eax, 4          ; syscall number for sys_write
    mov ebx, 1          ; file descriptor 1 is stdout
    mov ecx, hello      ; pointer to the string
    mov edx, 13         ; length of the string
    int 0x80            ; call kernel

    ; Exit the program
    mov eax, 1          ; syscall number for sys_exit
    xor ebx, ebx        ; return 0 status
    int 0x80            ; call kernel
```

Sequential execution (for most languages)

→ Pipeline code execution (Module 1)



CPU Clock



Program/Code Memory

	Address	Memory	Fetch / Decode	Execution
PC = 0	0	Instruction 0	Instruction 0	
PC = 1	1	Instruction 1	Instruction 1	Instruction 0
PC = 2	2	Instruction 2	Instruction 2	Instruction 1
PC = 3	3	Instruction 3	Instruction 3	Instruction 2
PC = 4	4	Instruction 4	Instruction 4	Instruction 3
	5	Instruction 5		
	6	Instruction 6		

Illustration: Datateknik course, W1 (T540050101, by Ali Sahafi)

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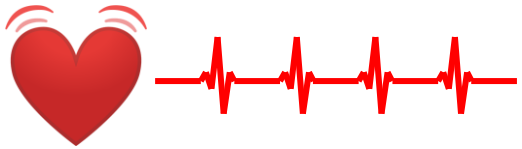

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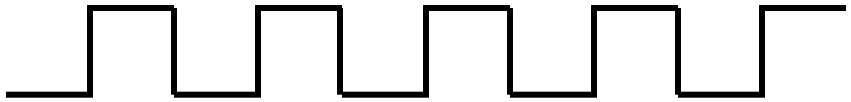

(Typically) **The same for the program execution**

- Each statement is executed one at the time
  - Starting from the top of the source code
  - …and then line-by-line down to the bottom…

- Next statement does not begin before the previous

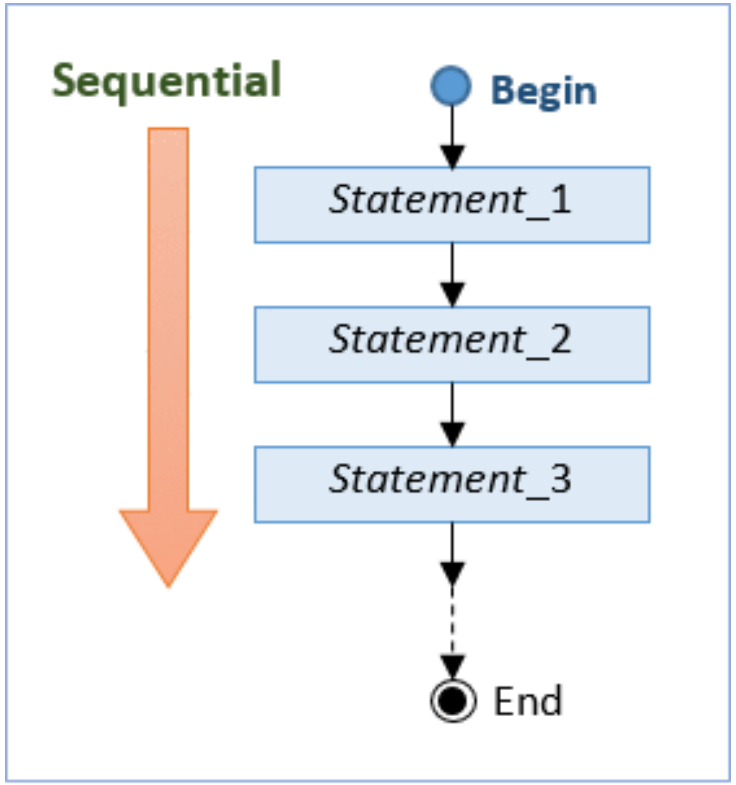

Illustration: https://www3.ntu.edu.sg/home/ehchua/Programming/java/J1a_Introduction.html

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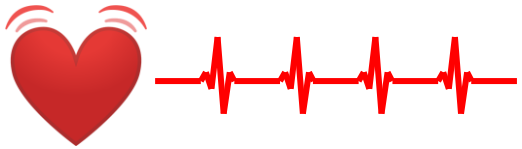

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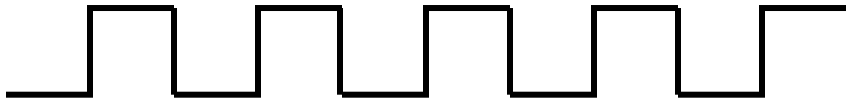

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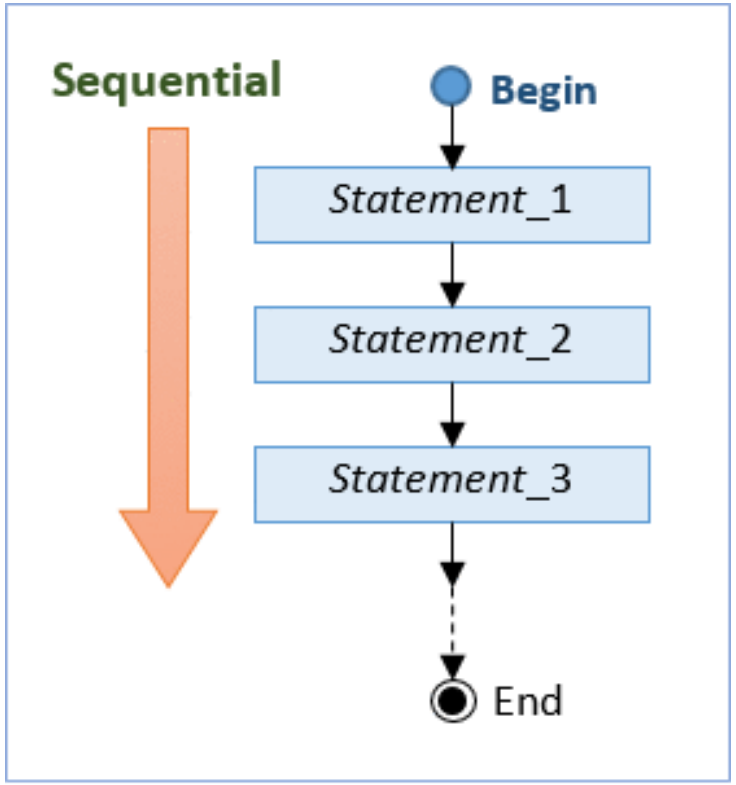
- Since the instructions are followed in order…
  - … it's easy to predict the output based on the input
  - …and debug, if there is an error.



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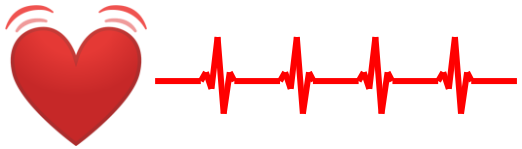

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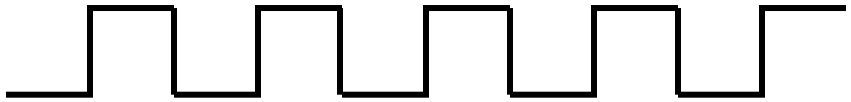

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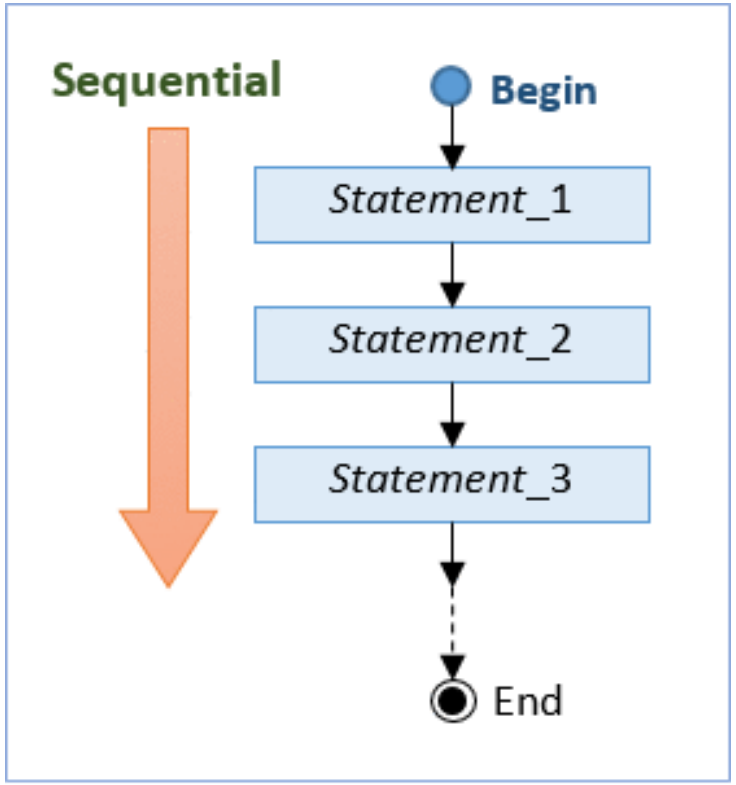
  - …and debug, if there is an error.
- **…and not entirely true…**
  - Control flows / branching is a exception (more about that later…)



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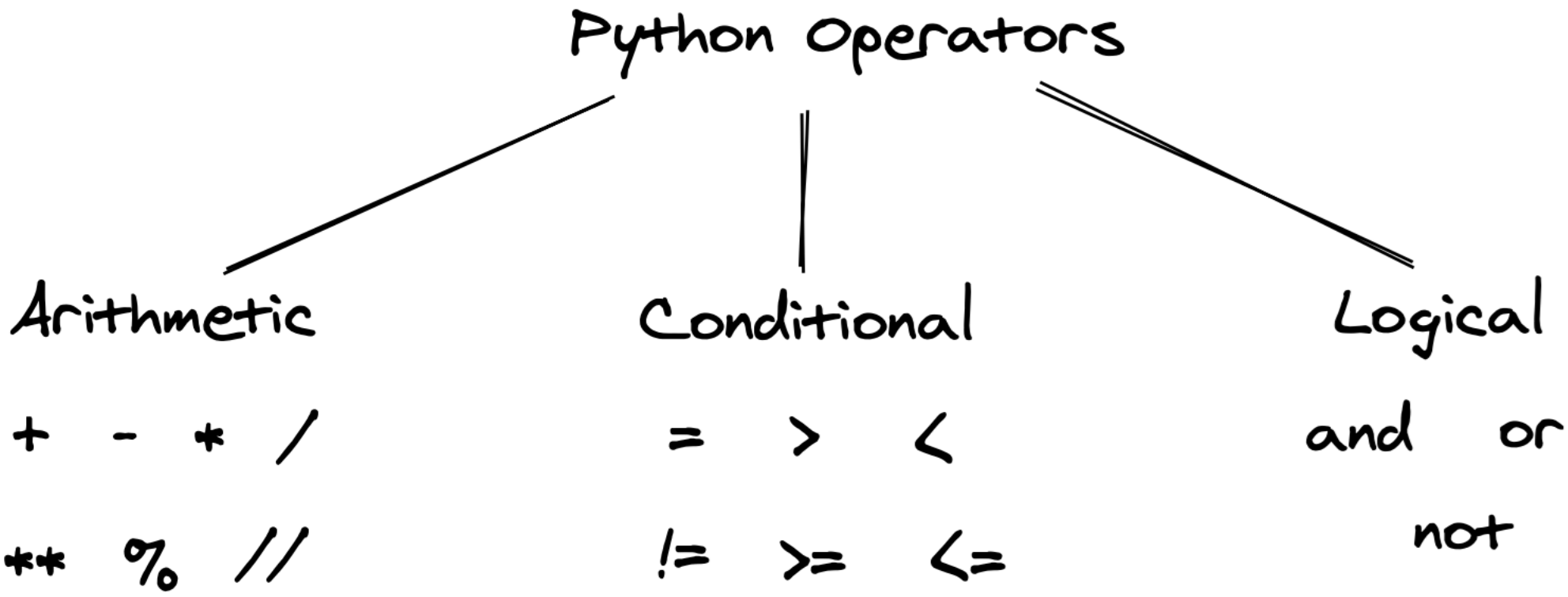

Illustration: https://jovian.ai/learn/data-analysis-with-python-zero-to-pandas

Arithmetic Operators

- Used with numeric values to perform **basic mathematical operations**

Operator	Purpose	Example	Result
+	**Addition**	2 + 3	5
-	**Subtraction**	3 - 2	1
*	**Multiplication**	8 * 12	96
/	**Division**	100 / 7	14.28571…
//	**Floor Division**	100 // 7	14
%	**Modulus/Remainder**	100 % 7	2
**	**Exponent**	5 ** 3	125

Conditional Operators

- Used comparing numbers and variables (returns either **True** or **False**)
  - Commonly in **conditional statements** and **loops**.

Operator	Purpose	Example	Result
==	**Check if operands are equal**	2 == 3	False
!=	**Check if operands are not equal**	3 != 2	True

Conditional Operators

- Used comparing numbers and variables (returns either **True** or **False**)
  - Commonly in **conditional statements** and **loops**.

Operator	Purpose	Example	Result
==	**Check if operands are equal**	2 == 3	False
!=	**Check if operands are not equal**	3 != 2	True
>	**Check if left operand is greater than right operand**	8 > 12	False
<	**Check if left operand is less than right operand**	8 < 12	True

Conditional Operators

- Used comparing numbers and variables (returns either **True** or **False**)
  - Commonly in **conditional statements** and **loops**.

Operator	Purpose	Example	Result
==	**Check if operands are equal**	2 == 3	False
!=	**Check if operands are not equal**	3 != 2	True
>	**Check if left operand is greater than right operand**	8 > 12	False
<	**Check if left operand is less than right operand**	8 < 12	True
>=	**Check if left operand is greater than or equal to right operand**	8 >= 8	True
<=	**Check if left operand is less than or equal to right operand**	8 <= 8	True

Logical Operators

- Used for combining conditions with logical operators (returns either True or False)
  - Commonly in conditional statements and loops.

a	b	a **and** b	a **or** b	not a	not b
True	**True**	True	True	False	False
True	**False**	False	True	False	True
False	**True**	False	True	True	False
False	**False**	False	False	True	True

- **And:** Returns True if both operands are True
- **Or:** Returns True if either of the operands are True
- **Not:** Returns True if the operand is False

Logical Operators

- Used for combining conditions with logical operators (returns either True or False)
  - Commonly in conditional statements and loops and **combined.**

a	b	a **and** b	a **or** b	not a **and** b	not (a **and** b)
True	**True**	True	True	False	False
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- **And:** Returns True if both operands are True
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In-class assignment (10 min)

Combining conditions with logical operators

```
my_favorite_number = 3
```

```
1) my_favorite_number > 0 and my_favorite_number <= 3
2) my_favorite_number > 0 or my_favorite_number <= 3
3) my_favorite_number == 0 or not my_favorite_number <= 3
4) not my_favorite_number > 0 or not my_favorite_number <= 3
5) not (my_favorite_number > 0 or not my_favorite_number <= 3)
```

a	**b**	a **and** b	a **or** b	**not** a	**not** b	not a **and** b	not (a **and** b)
True	**True**	True	True	False	False	False	False
True	**False**	False	True	False	True	False	True
False	**True**	False	True	True	False	True	True
False	**False**	False	False	True	True	False	True

Hand up (True) | Hand down (False)

```
my_favorite_number = 3
```

1) `my_favorite_number > 0 and my_favorite_number <= 3`
   a) ?
2) `my_favorite_number > 0 or my_favorite_number <= 3`
   a) ?
3) `my_favorite_number == 0 or not my_favorite_number <= 3`
   a) ?
4) `not my_favorite_number > 0 or not my_favorite_number <= 3`
   a) ?
5) `not (my_favorite_number > 0 or not my_favorite_number <= 3)`
   a) ?

Hand up (True) | Hand down (False)

```
my_favorite_number = 3
```

1) `my_favorite_number > 0 and my_favorite_number <= 3`
   a) `True and True = **True**`
2) `my_favorite_number > 0 or my_favorite_number <= 3`
   a) `?`
3) `my_favorite_number == 0 or not my_favorite_number <= 3`
   a) `?`
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2) `my_favorite_number > 0 or my_favorite_number <= 3`
   a) `True or True =` **`True`**
3) `my_favorite_number == 0 or not my_favorite_number <= 3`
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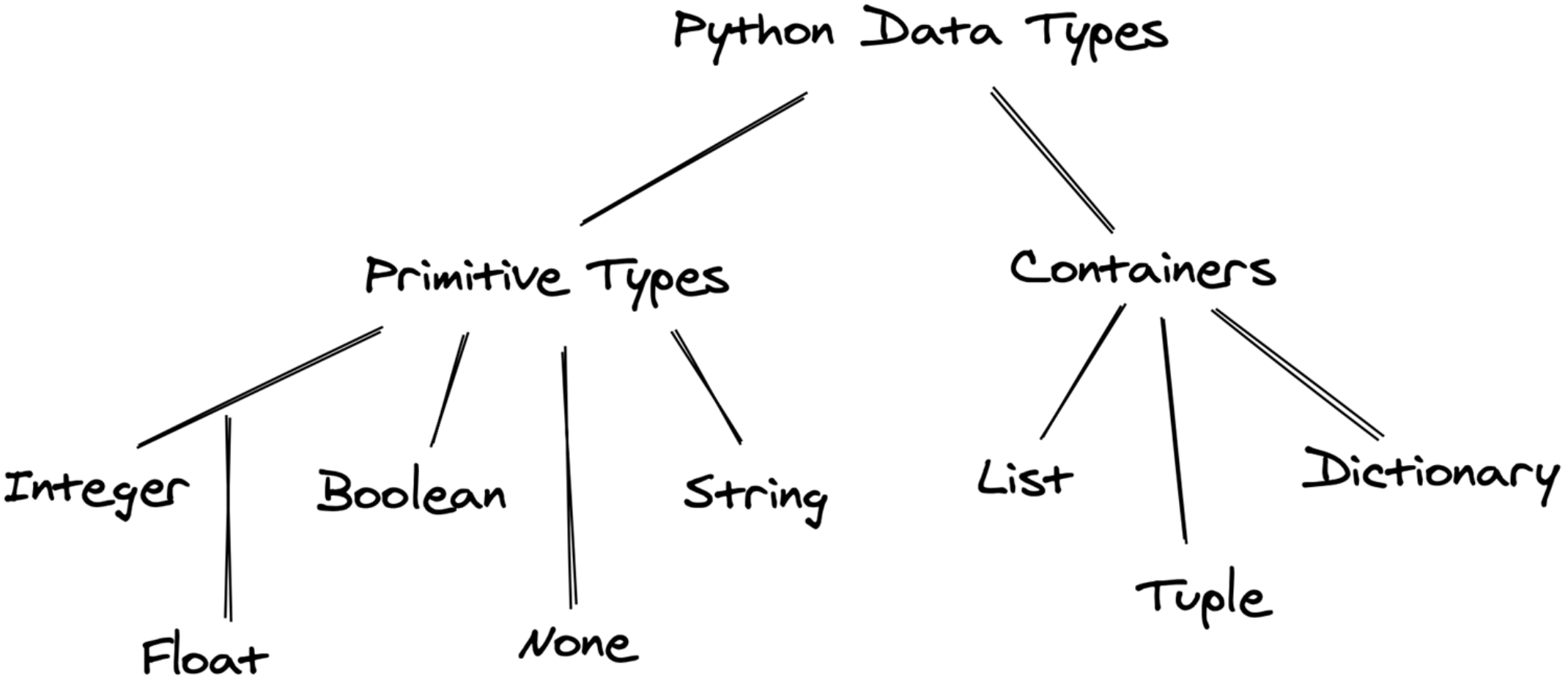
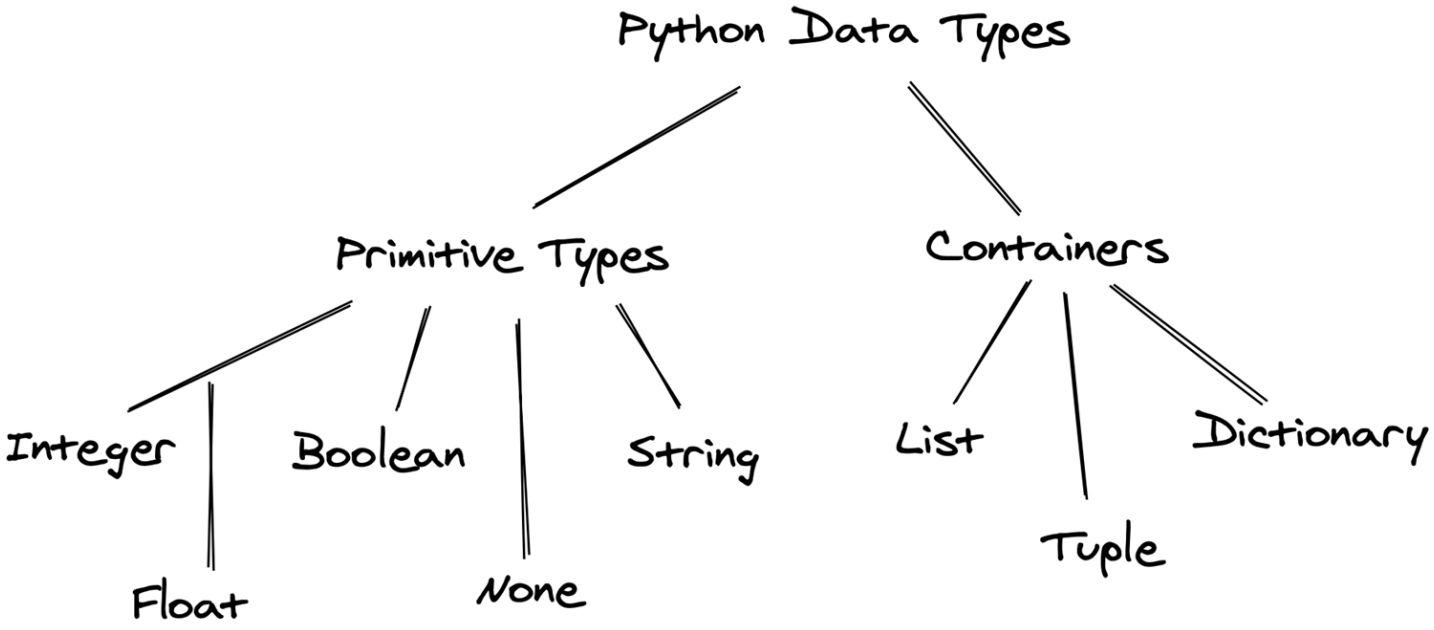


Illustration: https://jovian.ai/learn/data-analysis-with-python-zero-to-pandas

Data Type

"A classification that specifies the kind of value an object can have and what operations can be performed on that object."



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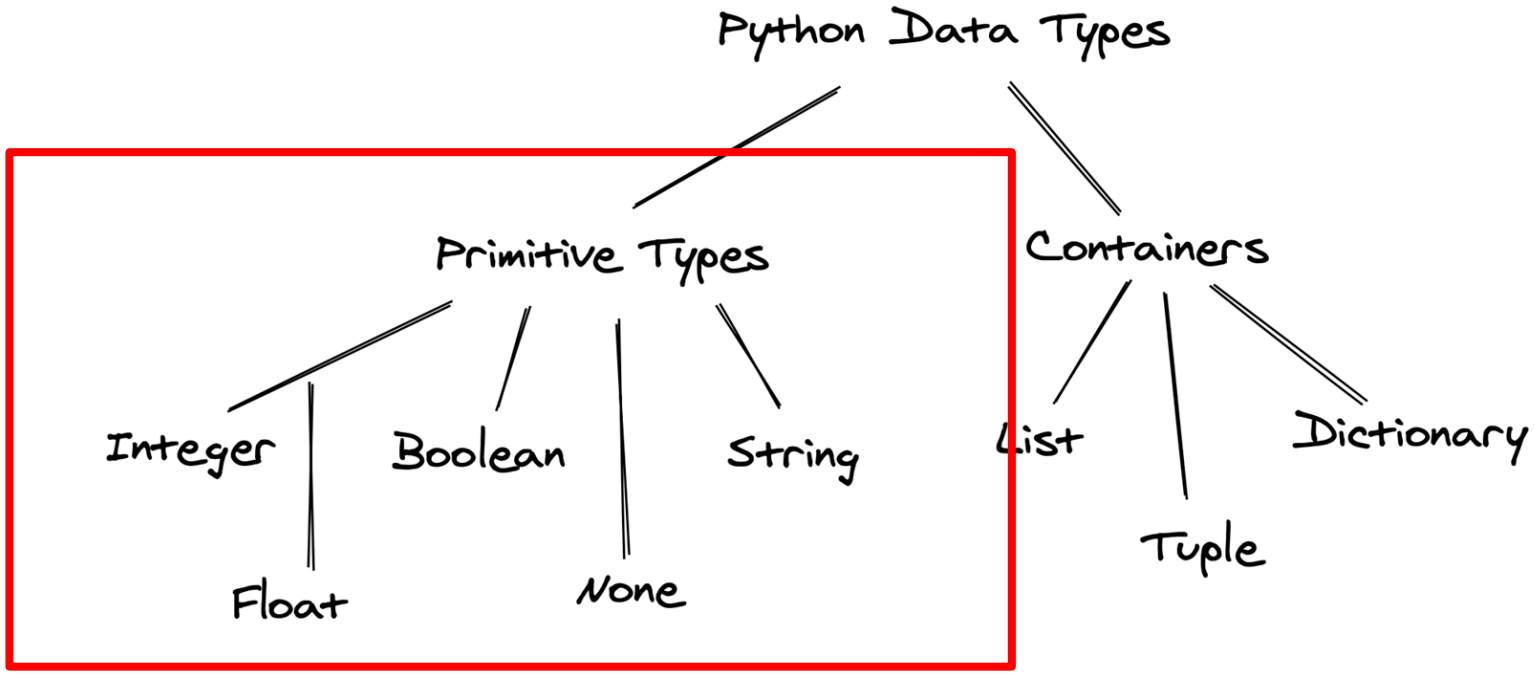

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  - **(String (str):** Represents a sequence of characters.)

Data Type

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- **Examples** (for different languages)

Data Type	Python	Java	C++	Size
Integer	int	byte (8-bit), short (16-bit), int (32-bit), long (64-bit)	char (8-bit), short (16-bit), int (32-bit), long (64-bit)	**8-bit to 64-bit**
Float	float	float (32-bit), double (64-bit)	float (32-bit), double (64-bit)	**32-bit (single-precision), 64-bit (double-precision)**
Char	Str	char	char	**8-bit**
String	str	String	std::string	**Variable size (depends on length)**
Boolean	bool	boolean	bool	**1 byte (typically)**
None	None	null	nullptr	

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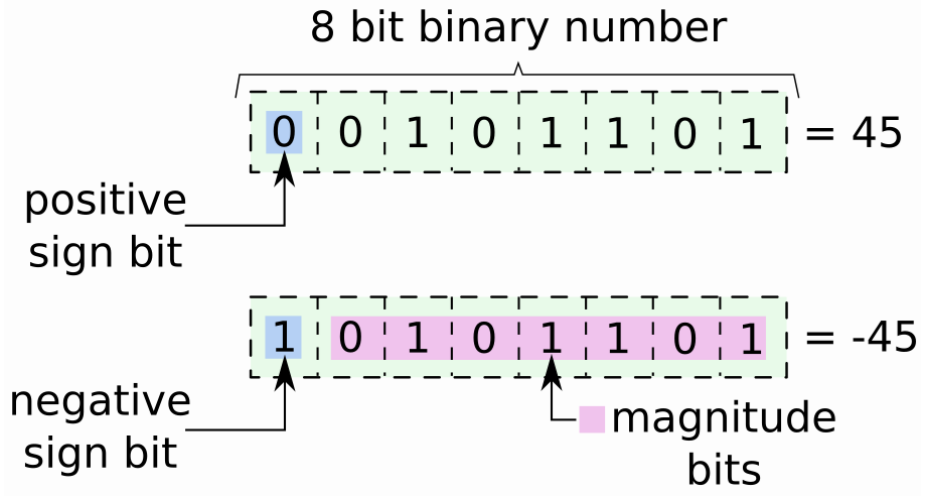
Integer Type	Signed Range (default)	Unsigned Range
8-bit	-128 to 127	0 to 255
16-bit	-32,768 to 32,767	0 to 65,535
32-bit	-2,147,483,648 to 2,147,483,647	0 to 4,294,967,295
64-bit	-9,223,372,036,854,775,808 to 9,223,372,036,854,775,807	0 to 18,446,744,073,709,551,615
Python (int)	Unbounded (limited by available memory)	

- Why?

Signed Int8



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- Why?
  - Optimizing memory usage
  - Range extension

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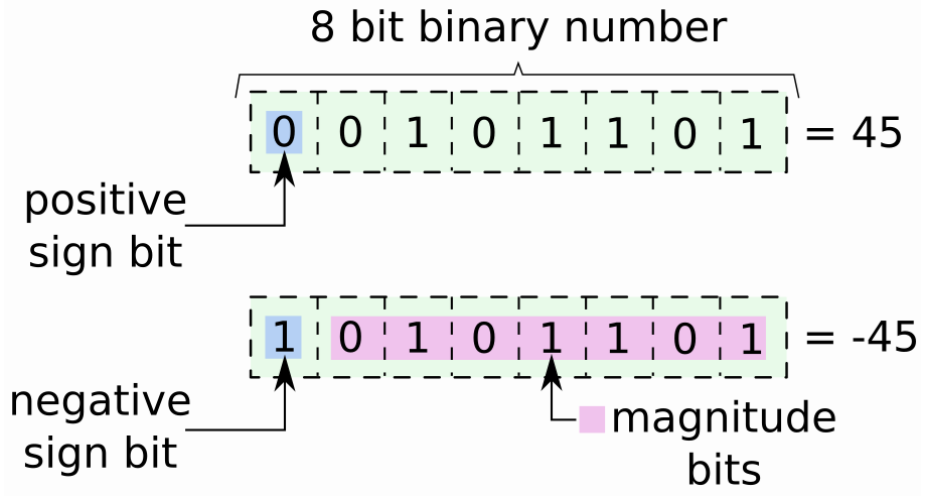


Variables

"A symbolic name that is a reference or pointer to an object."

- **Characteristics**
  - **Dynamic Typing** (in Python): The type of the variable is determined at runtime and can change during execution.
  - **Assignment:** Variables are assigned values using the " = " operator.
  - **Naming Rules**: Variable names must start with a letter or underscore, followed by letters, digits, or underscores (e.g., `my_var`, `_var`, `var1`).

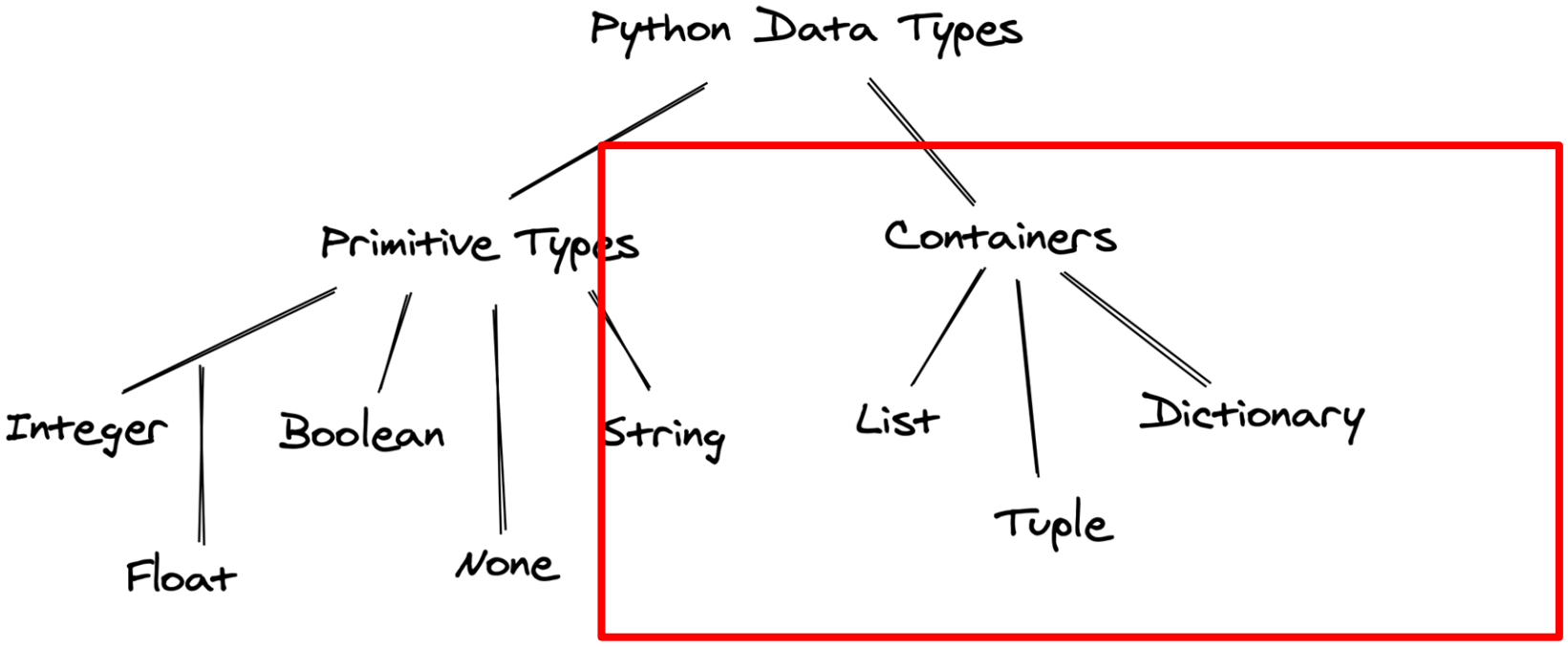
Python	C++

`age = 25`
`height = 5.9`
`name = "Alice"`
`is_student = True`
	`int age = 25;`
	`float height = 5.9f;`
	`std::string name = "Alice";`
	`bool is_student = true;`

Variables are assigned without specifying a type.	Variables must be declared with a type before assignment.

Containers

*"A symbolic name that is a reference or pointer an object that holds **a collection of other objects**."*



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Containers

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Container Type	Description	Example

List	Ordered, mutable, allows duplicate, indexable, Heterogeneous	`my_list = [1, 2, 3, 4]`
		`my_list.append(5)  # Adds 5 to the list`
		`my_list[0] = 10  # Changes the first element to 10`
		`print(my_list)  # Output: [10, 2, 3, 4, 5]`

Tuple	Ordered, immutable, allows duplicate, indexable, Heterogeneous	`my_tuple = (1, 2, 3, 4)`
		`print(my_tuple[1])  # Output: 2`
		`my_tuple[0] = 10 # This would raise a TypeError`

Dictionary	Unordered, mutable, keys are unique, not indexable, heterogeneous	`my_dict = {'a': 1, 'b': 2}`
		`my_dict['c'] = 3  # Adds a new key-value pair`
		`my_dict['a'] = 10  # Changes the value associated with key 'a'`
		`print(my_dict)  # Output: {'a': 10, 'b': 2, 'c': 3}`

Ordered: Elements maintain their insertion order / **Unordered:** Elements do not maintain their order.
Immutable: Once created, cannot be modified / **Mutable:** Can be modified after creation
Heterogeneous: Can store elements of different data types / **Homogeneous**: Can only store characters data types
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Containers

*"A symbolic name that is a reference or pointer an object that holds **a collection of other objects.**"*

Container Type	Description	Example

Set	Unordered collection of unique elements (no duplicates), mutable, not indexable, heterogeneous	`unique_numbers = {1, 2, 3, 3, 2}`
		`unique_numbers.add(4)  # Adds 4 to the set`
		`unique_numbers.remove(1)  # Removes 1 from the set`
		`print(unique_numbers)  # Output: {2, 3, 4}`

String	Ordered, immutable sequence of characters (homogeneous), supports slicing, Indexable	`greeting = "hello"`
		`print(greeting[1])  # Output: 'e'`
		`greeting[1] = 's'  # Error`

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Built-in functions (Python):

- Predefined functions always available and do not require importing any modules.

- These functions perform various operations such as:
  - mathematical calculations, type conversions, input/output operations, and data manipulation.

Built-in Functions (Python)			
A abs() aiter() all() anext() any() ascii() **B** bin() bool() breakpoint() bytearray() bytes() **C** callable() chr() classmethod() compile() complex() **D** delattr() dict() dir() divmod()	**E** enumerate() eval() exec() **F** filter() float() format() frozenset() **G** getattr() globals() **H** hasattr() hash() help() hex() **I** id() input() int() isinstance() issubclass() iter()	**L** len() list() locals() **M** map() max() memoryview() min() **N** next() **O** object() oct() open() ord() **P** pow() print() property()	**R** range() repr() reversed() round() **S** set() setattr() slice() sorted() staticmethod() str() sum() super() **T** tuple() type() **V** vars() **Z** zip() _ __import__()

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Worth mentioning (especially for debugging…)

- **Type:** Get the data type of a variable with the `type()` function.

- **Casting (in Python):** Setting the Specific Data Type

    - Why?

Worth mentioning (especially for debugging…)

- **Type:** Get the data type of a variable with the `type()` function.

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  - Why?
    - …some operations require the operands to be of the same type.
    - …convert between container (Homogeneous).
    - …handling user inputs, eg. a calculator?

Worth mentioning (especially for debugging…)

- **Type:** Get the data type of a variable with the `type()` function.

- **Casting (in Python):** Setting the Specific Data Type
  - If you want to specify the data type of a variable, this can be done with casting.
    - `int()` - constructs an integer number from an integer literal, a float literal (by removing all decimals), or a string literal (providing the string represents a whole number)
    - `float()` - constructs a float number from an integer literal, a float literal or a string literal (providing the string represents a float or an integer)
    - `str()` - constructs a string from a wide variety of data types, including strings, integer literals and float literals

Example: Casting and type using **Python**

String to Integer

```
s = '456'
print(type(s)) # Output: <class 'str'>
int_s = int(s)
print(int_s) # Output: 456
print(type(int_s)) # Output: <class 'int'>
```

Float to String

```
num = 3.14
str_num = str(num)
print(str_num)  # Output: '3.14'
print(type(str_num)) # Output: <class 'str'>
```

Float to Integer

```
f = 10.7
int_f = int(f)
print(int_f)  # Output: 10
print(type(int_f))  # Output: <class 'int'>
```

Worth mentioning (especially for debugging…)

- **Type:** Get the data type of a variable with the `type()` function.

- **Casting (comparison):** Setting the Specific Data Type
  - If you want to specify the data type of a variable, this can be done with casting.

Examples: Float to Integer (comparison between programming languages)

Python

```python
float_number = 12.34
int_number = int(float_number)
print(int_number)  # Output: 12
```

C++

```cpp
#include <iostream>
using namespace std;

int main() {
    float float_number = 12.34;
    int int_number = static_cast<int>(float_number);
    cout << int_number << endl;  // Output: 12
    return 0;
}
```

Java

```java
public class Main {
    public static void main(String[] args) {
        double floatNumber = 12.34;
        int intNumber = (int) floatNumber;
        System.out.println(intNumber);  // Output: 12
    }
}
```

Length: Get the number of items in an object using the `len()` function.

Object Type	Example	Example	Output	Description
String	`my_string = "Hello, World!"`	`type(my_string)` `len(my_string)`	`<class 'str'>` `13`	Number of characters in the string
List	`my_list = [1, 2, 3, 4, 5]`	`type(my_list)` `len(my_list)`	`<class 'list'>` `5`	Number of elements in the list
Tuple	`my_tuple = (10, 20, 30, 40)`	`type(my_tuple)` `len(my_tuple)`	`<class 'tuple'>` `4`	Number of items in the tuple
Dictionary	`my_dict = {'a': 1, 'b': 2, 'c': 3}`	`type(my_dict)` `len(my_dict)`	`<class 'dict'>` `3`	Number of key-value pairs in the dictionary
Set	`my_set = {1, 2, 3, 4, 5}`	`type(my_set)` `len(my_set)`	`<class 'set'>` `5`	Number of unique elements in the set

Nested List	`nested_list = [ [1, 2, 3], [4, 5], [6] ]`	`type(nested_list)`
		`len(nested_list)`
		`len(nested_list[1])`
			`<class 'list'>`
			`3`
			`2`
				Number of sublists in the nested list

Range: Generate a sequence of numbers using the `range()` function, especially within a for loop.

List the numbers from 0 to 5

```
numbers = list(range(5))
print(numbers) # Output: [0, 1, 2, 3, 4]
```

List the numbers based on the length of the Tuple

```
my_tuple = (10, 20, 30, 40)
numbers = list(range(len(my_tuple)))
print(numbers) # Output: [0, 1, 2, 3]
```

Task: Python Operators and Data Types (40 min / 10.00)

(Assuming that you have the ***hello_world.ipynb*** up-and-running)

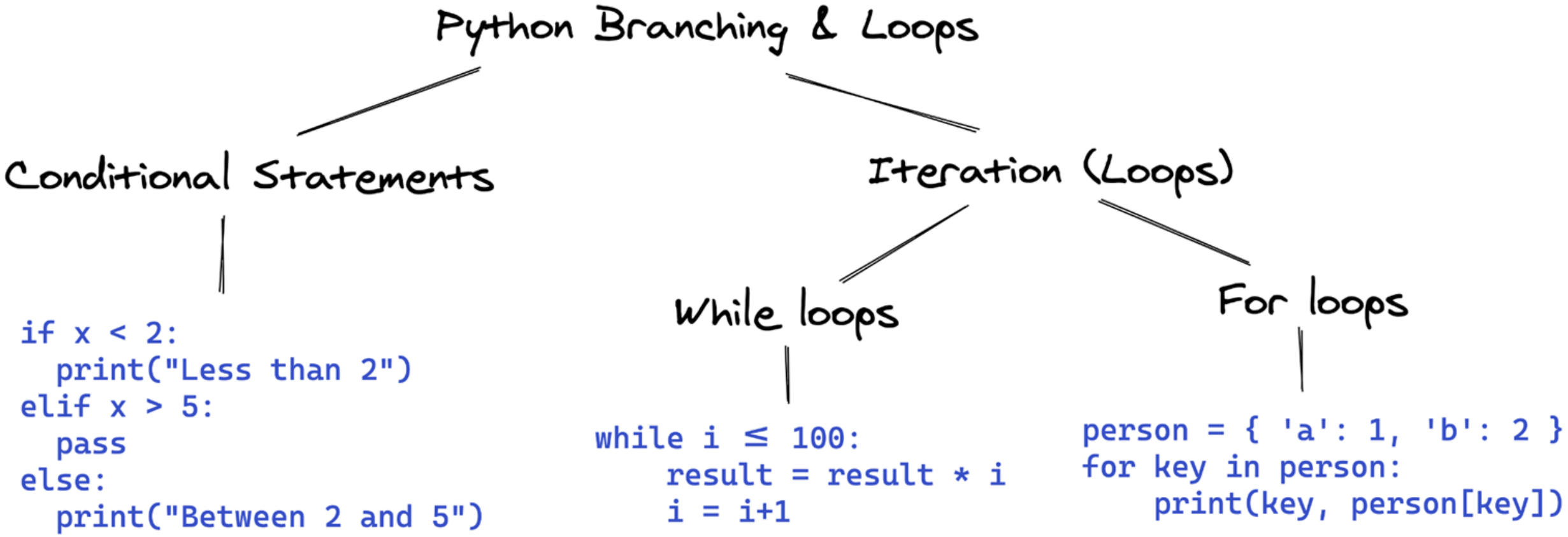
1. Go to ItsLearning, and download the ***pmr_02_exercises.ipynb***

2. Run it in the same environment as you teste the ***hello_world.ipynb***

3. Get as far as you can with:
   a. **Assignment #1:** Performing Arithmetic Operations using Python
   b. **Assignment #2:** Variables and Data Types in Python

(if you finished #1 and #2 within the timeframe,

start answering the questions in the bottom of the file)



Source: https://jovian.ai/learn/data-analysis-with-python-zero-to-pandas

Branching

“A fundamental concept in programming that allows you to control the flow of your program based on conditions.”

= moving the Program Counter to a new address

…causing the CPU to begin executing a different instruction sequence.

Branching

“A fundamental concept in programming that allows you to control the flow of your program based on conditions.”

= moving the Program Counter to a new address

…causing the CPU to begin executing a different instruction sequence

- ***Conditional*** *branch (conditional statements):*
  - may or may not cause branching depending on some condition.

- ***Unconditional*** *branch (iterations / loops):*
  - always results in branching

Conditional statements

“A fundamental construct in programming that allows you to execute specific blocks of code based on whether a condition is `True` or `False`“

Usage:

- **Condition**: An expression that evaluates to `True` or `False`.
- **Control Statements**: `if`, `else`, `elif`.

Conditional statements

"A fundamental construct in programming that allows you to execute specific blocks of code based on whether a condition is `True` or `False`"

Syntax and usage:

- **Condition**: An expression that evaluates to `True` or `False`.
- **Control Statements**: `if` `else` `elif`

Example: If ... Else syntax

Python

```
if condition1:
    # Code to execute if condition1 is true
elif condition2:
    # Code to execute if condition2 is true
else:
    # Code to execute if none of the above conditions are true
```

C++

```
if (condition1) {
    // Code to execute if condition1 is true
} else if (condition2) {
    // Code to execute if condition2 is true
} else {
    // Code to execute if none of the above conditions are true
}
```

Uses **indentation** to indicate a block of code.	Uses **curly brackets** to indicate a block of code.

Conditional statements

"A fundamental construct in programming that allows you to execute specific blocks of code based on whether a condition is `True` or `False`"

Example: If ... Else

```
age = 20

if age < 18:
    print("You are a minor.")
elif age >= 18 and age < 65:
    print("You are an adult.")
else:
    print("You are a senior citizen.")
```

Conditional statement If ... Else

```
age = 20
has_license = True

if age >= 18 and has_license:
    print("You are allowed to drive.") # Result
else:
    print("You are not allowed to drive.")
```

Combining conditions with Logical Operators

```
age = 20
has_license = False

if age >= 18:
    if has_license:
        print("You are allowed to drive.")
    else:
        print("You need a license to drive.")
# Result
else:
    print("You are not allowed to drive.")
```

Nested If ... Else

Conditional statements (Shorthand If .. Else, a bit C/C++-like syntax)

Example: Shorthand If ... Else

```
a = 5
b = 4

# Short Hand If
if a > b: print("a is greater than b")

# Short Hand If ... Else
print("A") if a > b else print("B")
print("A") if a > b else print("=") if a == b else print("B")
```

Conditional statements

- **If ... Else** versus **Match**?
  a. **Match:** Introduced in Python 3.10, same purpose, more modern/readable syntax.
     i. (Similar to switch-cases in C++)

Example: Comparison

```
# Define the animal type
animal = "dog"

# Categorize the animal
if animal == "dog":
    print("This is a mammal.")
elif animal == "eagle":
    print("This is a bird.")
elif animal == "shark":
    print("This is a fish.")
elif animal == "frog":
    print("This is an amphibian.")
elif animal == "crocodile":
    print("This is a reptile.")
else:
    print("Unknown animal type.")
```

```
# Define the animal type
animal = "dog"

# Categorize the animal using match
match animal:
    case "dog":
        print("This is a mammal.")
    case "eagle":
        print("This is a bird.")
    case "shark":
        print("This is a fish.")
    case "frog":
        print("This is an amphibian.")
    case "crocodile":
        print("This is a reptile.")
    case _:
        print("Unknown animal type.")
```

Loops

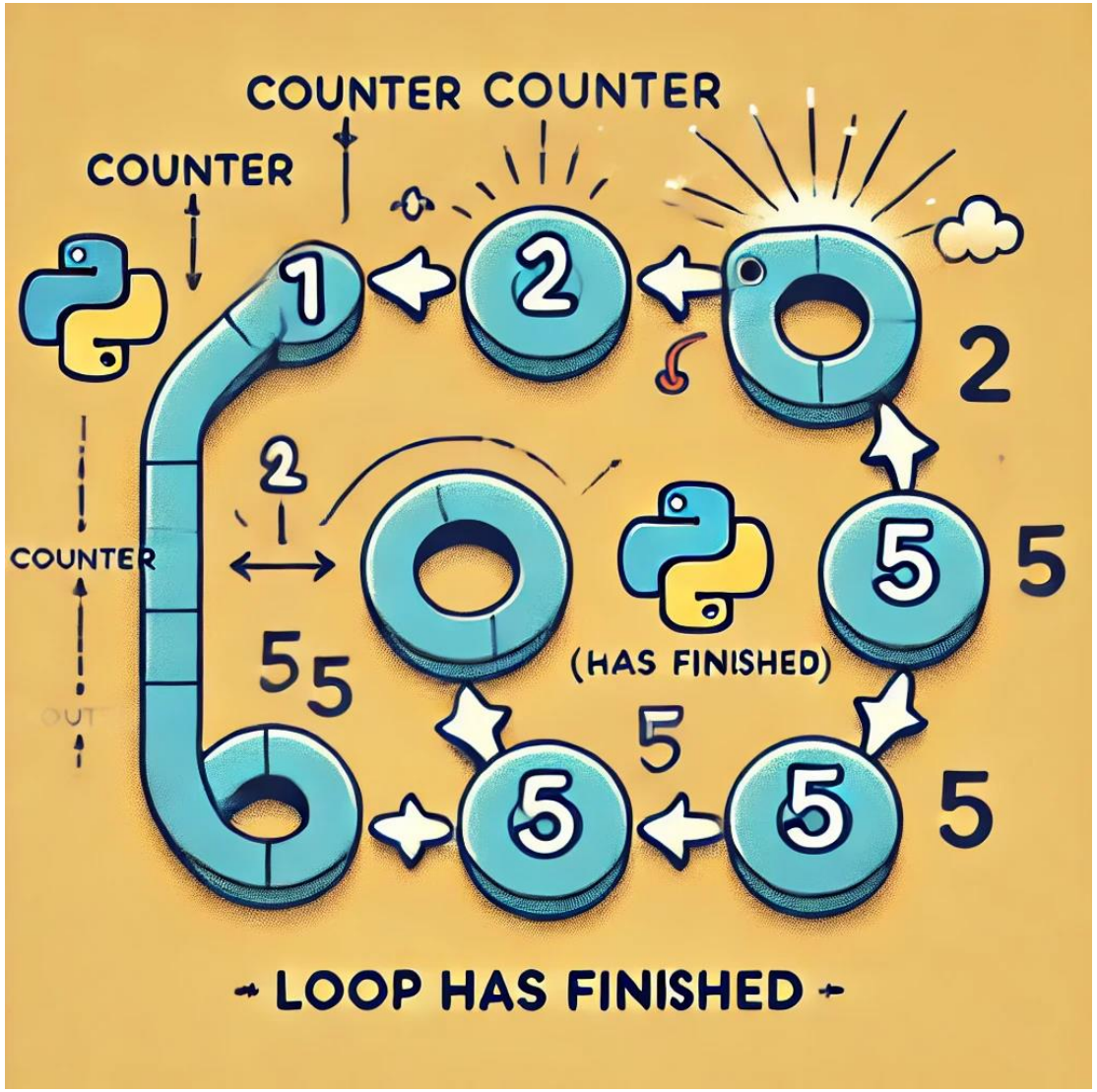


Illustration: generated using OpenAI's DALL·E tool

Loops

"A fundamental concept in programming that allow you to execute a block of code multiple times."

- ***For loop:*** iterating over a sequence or container (such as a list, tuple, set, or string).

- ***While loop:*** repeatedly executes a block of code as long as a given condition is true.

Example: Comparison in the programming syntax	
Python	**C++**

`for condition:`
`  # Code to execute if condition is true`
	`for (condition) {`
	`  // Code to execute if condition is true`
	`}`

`while condition:`
`  # Code to execute if condition is true`
	`while (condition) {`
	`  // Code to execute if condition is true`
	`}`

Uses indentation to indicate a block of code.	Uses curly brackets to indicate a block of code.

Loops

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- ***For loop:*** iterating over a sequence or container (such as a list, tuple, set, or string).
- ***While loop:*** repeatedly executes a block of code as long as a given condition is true.
- **Control Statements**: `break`, `continue`, `return`, and ~~`goto`~~ (in some languages).

Example: Comparison in the programming syntax	
Python	**C++**

`for condition:`
`  # Code to execute if condition is true`
	`for (condition) {`
	`  // Code to execute if condition is true`
	`}`

`while condition:`
`  # Code to execute if condition is true`
	`while (condition) {`
	`  // Code to execute if condition is true`
	`}`

Uses indentation to indicate a block of code.	Uses curly brackets to indicate a block of code.

Loops (key concepts)

- ***For loop:*** iterating over a sequence or container (such as a list, tuple, set, or string).

Example: Syntax	
Python	**Example**

`for condition:`
`  # Code to execute if condition is true`
	`fruits = ["apple", "banana", "cherry"]`
	
	`for fruit in range(len(fruits)):`
	`  print(fruits[fruit])`

	`fruits = ["apple", "banana", "cherry"]`
	
	`for fruit in fruits:`
	`  print(fruit)`
	
	`# Both examples prints:`
	`# apple`
	`# banana`
	`# cherry`

Loops (key concepts)

- ***Nested For loop:*** iterating over a sequence/container of sequences/containers.

Example: Iterating Over a List of Lists

```
for outer_variable in outer_sequence:
    for inner_variable in inner_sequence:
        # Code to execute
```

```
matrix = [
    [1, 2, 3],
    [4, 5, 6],
    [7, 8, 9]
]

for row in matrix:
    for element in row:
        print(element, end=' ')
    print()  # For new line after each row

# Prints
# 1 2 3
# 4 5 6
# 7 8 9
```

Loops (key concepts)

- ***Nested For loop:*** iterating over a sequence/container of sequences/containers.

Example: Iterating Over a List of Lists

```
for outer_variable in outer_sequence:
    for inner_variable in inner_sequence:
        # Code to execute
```

Outer Loop: The first loop iterates through the outer sequence (e.g., rows in a matrix, or the first list in a pair generation).

Inner Loop: The nested loop iterates through the inner sequence (e.g., elements within a row, or the second list in a pair generation).

```
matrix = [
    [1, 2, 3],
    [4, 5, 6],
    [7, 8, 9]
]

for row in matrix:
    for element in row:
        print(element, end=' ')
    print()  # For new line after each row

# Prints
# 1 2 3
# 4 5 6
# 7 8 9
```

Loops (key concepts)

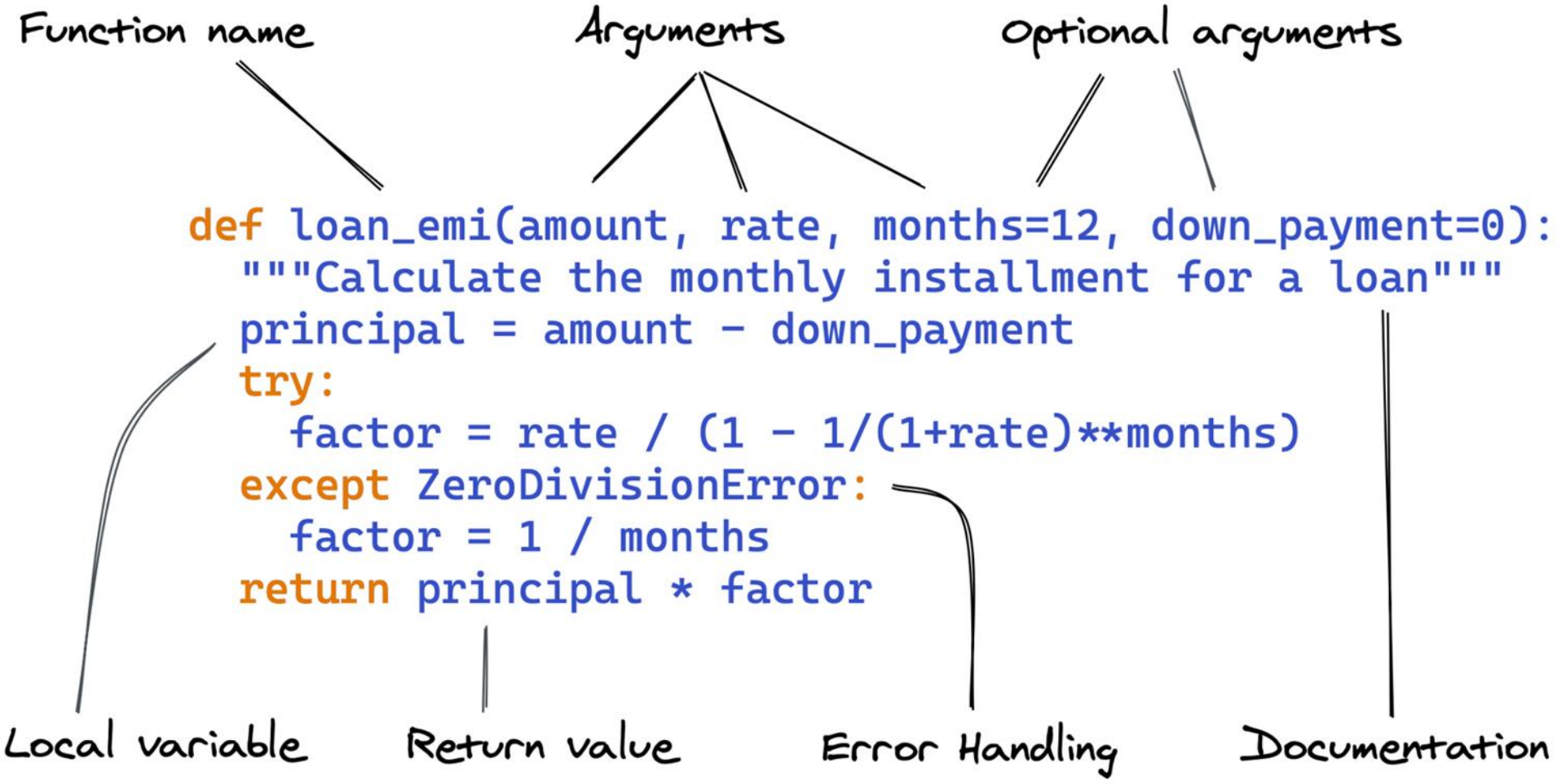
- ***While loop:*** repeatedly executes a block of code as long as a given condition is true

Example: Syntax

Python	Example

`while condition:`
`  # Code to execute if condition is true`
	`i = 0`
	
	`while True: # Count forever....`
	`  print(i)`
	`  i += 1`

`ready = get_status()`
 	
`while not ready: # Keep looping until ready....`
`  ready = get_status()`
 	
`# Continue when ready!`
	`i = 0`
	
	`while i < 5: # Count 0 . . . 4`
	`  print(i)`
	`  i += 1`



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Function

“A block of reusable code that performs a specific task”

Syntax and usage:

- ***Redundancy:*** Reusing code blocks
- ***Readability:*** Organizes your code by moving parts out of your main loop

Syntax: Python	Example: Define a function

`def function_name(parameters):`
`  # Function body`
`  return value  # (optional) return statement`
	`# Print “Hello, World!”`
	`print("Hello, World!")`

Start by using the `def` keyword, followed by the function name and parentheses. Inside the parentheses, you can list any parameters the function will accept. Uses indentation to indicate a block of code.	

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Syntax: Python	Example: Define a function

`def function_name(parameters):`
`  # Function body`
`  return value  # (optional) return statement`
	`def hello():`
	`  print("Hello, World!")`
	
	`# Calling the function`
	`hello()`

Start by using the `def` keyword, followed by the function name and parentheses. Inside the parentheses, you can list any parameters the function will accept. Uses indentation to indicate a block of code.	

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Syntax: Python	Example: Implement argument

`def function_name(parameters):`
`  # Function body`
`  return value  # (optional) return statement`
	`def hello(name):`
	`  print(f"Hello, {name}!")`
	
	`# Calling the function`
	`hello("Jes") # Output: Hello, Jes!`

Start by using the `def` keyword, followed by the function name and parentheses. Inside the parentheses, you can list any parameters the function will accept. Uses indentation to indicate a block of code.	

Function

“A block of reusable code that performs a specific task”

Syntax and usage:

- ***Redundancy:*** Reusing code blocks
- ***Readability:*** Organizes your code by moving parts out of your main loop

Syntax: Python	Example: Implement default argument

`def function_name(parameters):`
`  # Function body`
`  return value  # (optional) return statement`
	`def hello(name="World"):`
	`  print(f"Hello, {name}!")`
	
	`# Calling the function`
	`hello() # Output: Hello, World!`
	`hello("Jes") # Output: Hello, Jes!`

Start by using the `def` keyword, followed by the function name and parentheses. Inside the parentheses, you can list any parameters the function will accept. Uses indentation to indicate a block of code.	

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Syntax and usage:

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Syntax: Python	Example: Implement default argument

`def function_name(parameters):`
`  # Function body`
`  return value  # (optional) return statement`
	`def hello(name="World"):`
	`  """`
	`  This function prints a personalized greeting message.`
	
	`  :param name: The name of the person to greet. Default: "World".`
	`  """`
	`  print(f"Hello, {name}!")`
	
	`# Calling the function`
	`hello("Jes") # Output: Hello, Jes!`

Start by using the `def` keyword, followed by the function name and parentheses. Inside the parentheses, you can list any parameters the function will accept. Uses indentation to indicate a block of code.	

Function

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Syntax and usage:

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Syntax: Python	Example: Handle Multiple Greetings (improving)

`def function_name(parameters):`
`  # Function body`
`  return value  # (optional) return statement`
	`def hello(*names):`
	`  """`
	`  This function prints a greeting message for each name provided.`
	
	`  :param names: A list of names to greet.`
	`  """`
	`  for name in names:`
	`  print(f"Hello, {name}!")`
	
	`# Calling the function`
	`hello("Jes", "Bo", "Hans")`
	`# Output: Hello, Jes! Hello, Bo! Hello, Hans!`

Start by using the `def` keyword, followed by the function name and parentheses. Inside the parentheses, you can list any parameters the function will accept. Uses indentation to indicate a block of code.	

Scope

"The scope of a variable refers to the region of the code where the variable is recognized."

Syntax and usage:

- ***Global scope:*** A variable defined in the main body of the Python code is a global variable. It can be accessed anywhere in the code, both inside and outside functions.

- ***Local scope:*** A variable defined inside a function is a local variable. It can only be accessed within that function and not outside.

Example: Global scope

```
x = 10  # Global variable

def print_global():
    print(x)  # Accessing the global variable

print_global()  # Output: 10
print(x)  # Output: 10
```

Example: Local scope

```
def print_local():
    x = 5  # Local variable
    print(x)  # Accessing the local variable

print_local()  # Output: 5
print(x)  # Error: NameError: name 'x' is not defined
```

Scope

“The scope of a variable refers to the region of the code where the variable is recognized.”

Syntax and usage:

- ***Global Keyword:*** If you need to modify a global variable inside a function, you can use the global keyword. This keyword tells Python that you are referring to the global variable, not a local one.

Example: Local scope

```
x = 10  # Global variable

def print_global():
    global x  # Accessing the global variable
    print(x)
    x += 1 # Modifying the global variable

print_global()  # Output: 10
print(x)  # Output: 11
```

Troubleshooting and Debugging

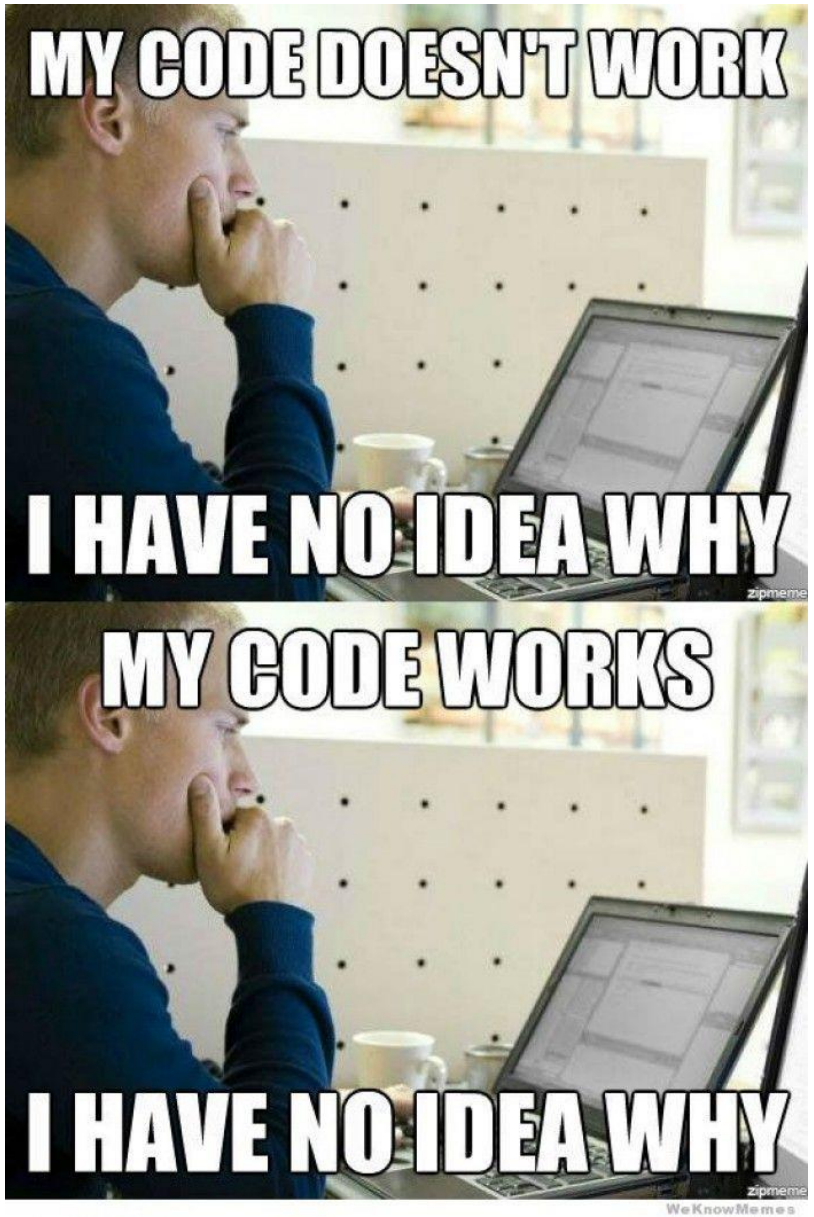
Troubleshooting and Debugging

"...identifying, diagnosing, and resolving errors or bugs that arise when writing or running the code."

Best practise:

"Try again, ask a friend, ask an adult…"

- …when you get an error, look at the:
  - **Error Type**: The type of error (e.g., SyntaxError, TypeError, ValueError).
  - **Traceback**: A list showing the sequence of calls that led to the error.
  - **Error Message**: A description of what caused the error (e.g., "division by zero").



Troubleshooting and Debugging

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Common errors (in Python)**:**

- **Syntax Errors:** Occur when the interpreter encounters code that doesn't conform to the language's syntax rules.
- **Indentation Errors:** Misaligned or inconsistent indentation can lead to errors.
- **Name Errors:** A variable or function is used before it's defined or misspelled.
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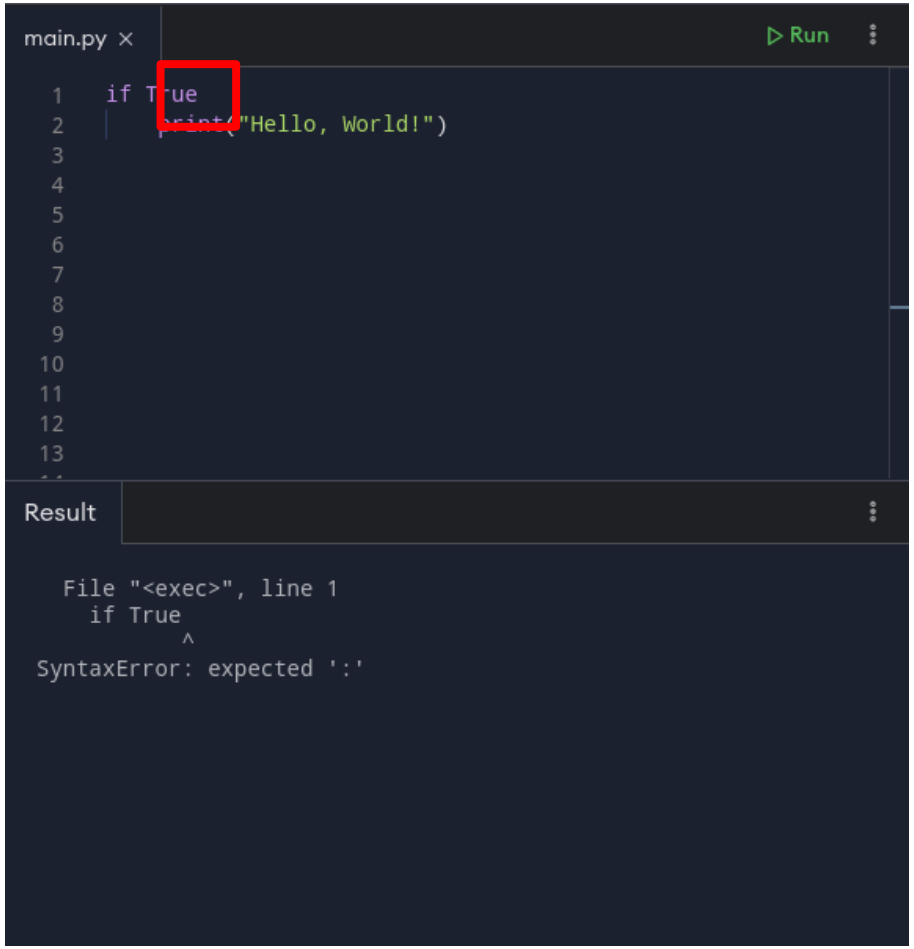

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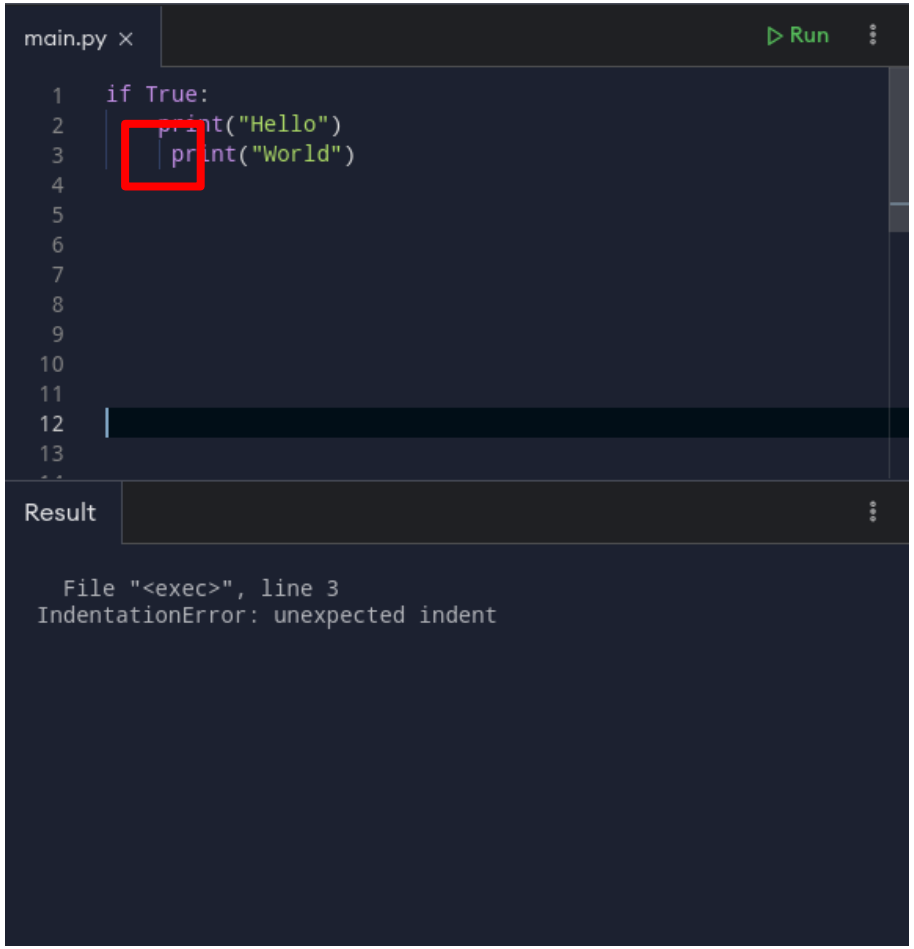

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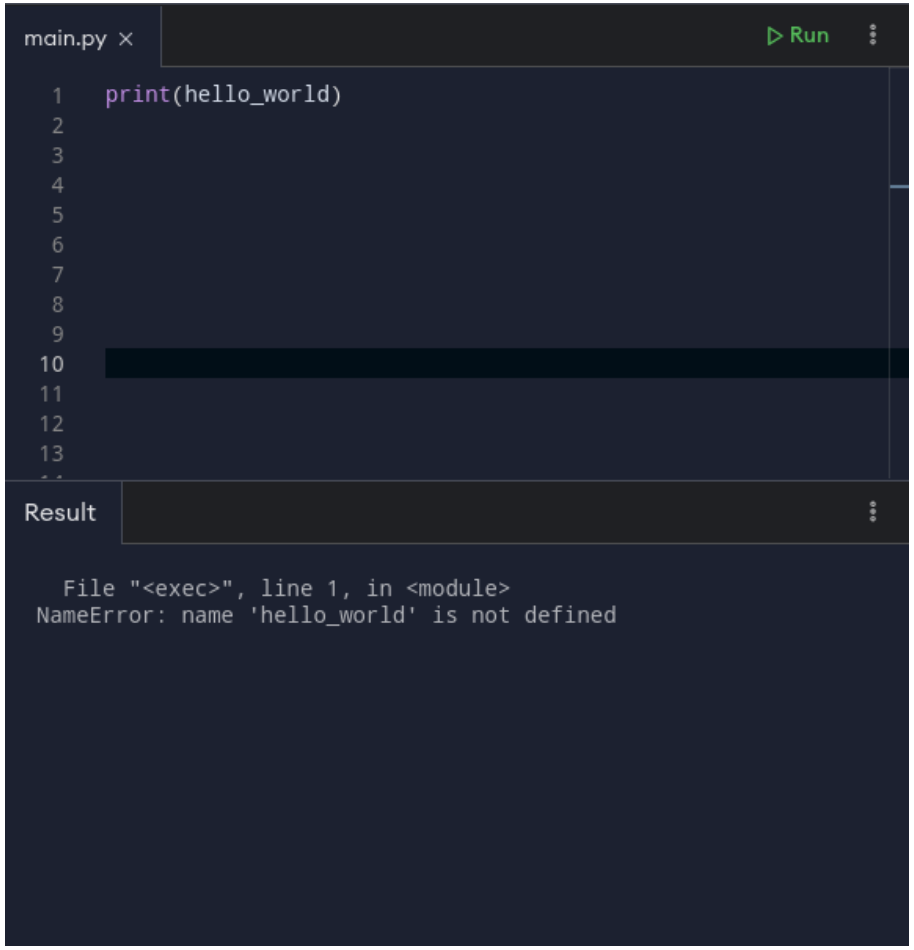

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  - **How to fix this?**
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  - How to fix this? **Casting…**
- **Index/Key Errors:** When trying to access an index that is out of range in a list or string, or trying to access a dictionary with a key that does not exist.
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(Most) Common errors (in Python)**:**

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- **Index/Key Errors:** When trying to access an index that is out of range in a list or string, or trying to access a dictionary with a key that does not exist.
    - **How to fix this?**
- **Value Errors:** When a function receives an argument of the correct type but an inappropriate value.

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Troubleshooting and Debugging

"...identifying, diagnosing, and resolving errors or bugs that arise when writing or running the code."

Debugging Techniques

- **Print Statements:** Inserting print() statements in your code can help track the flow of execution and check the values of variables at different points.

Example: Using `print()` for debugging

```
print("I'm here")

...

print("Now I'm here...")

...

print("Counter: {}".format(counter) )
print("Counter: {}".format(type(counter)) )
```

Troubleshooting and Debugging

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Debugging Techniques

- **Print Statements:** Inserting print() statements in your code can help track the flow of execution and check the values of variables at different points.
- **Try-Except Blocks:** Use try-except blocks to catch and handle exceptions, which can help prevent your program from crashing and allow you to manage errors gracefully.

Example: Try-Except Block

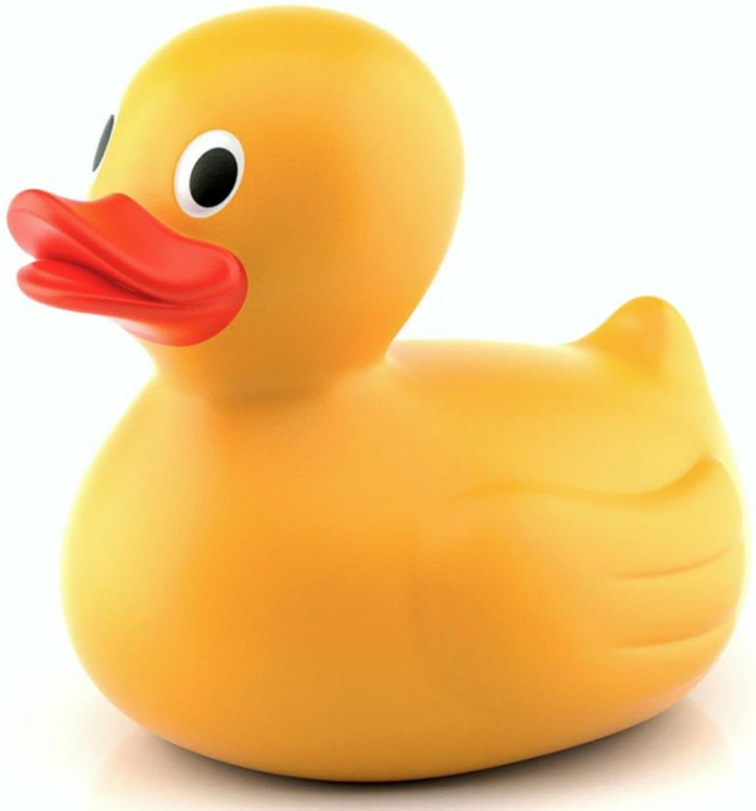
```
try:
    result = 10 / 0
except ZeroDivisionError as e:
    print(f"Error: {e}")
    # Prints --> Error: division by zero
```

Troubleshooting and Debugging

"...identifying, diagnosing, and resolving errors or bugs that arise when writing or running the code."

Debugging Techniques

- **Print Statements:** Inserting print() statements in your code can help track the flow of execution and check the values of variables at different points.
- **Try-Except Blocks:** Use try-except blocks to catch and handle exceptions, which can help prevent your program from crashing and allow you to manage errors gracefully.
- **Rubberdugging / Rubber Duck Debugging:** Explaining your code, often to an inanimate object like a rubber duck, can help clarify your thinking and reveal bugs you might have missed.



Troubleshooting and Debugging

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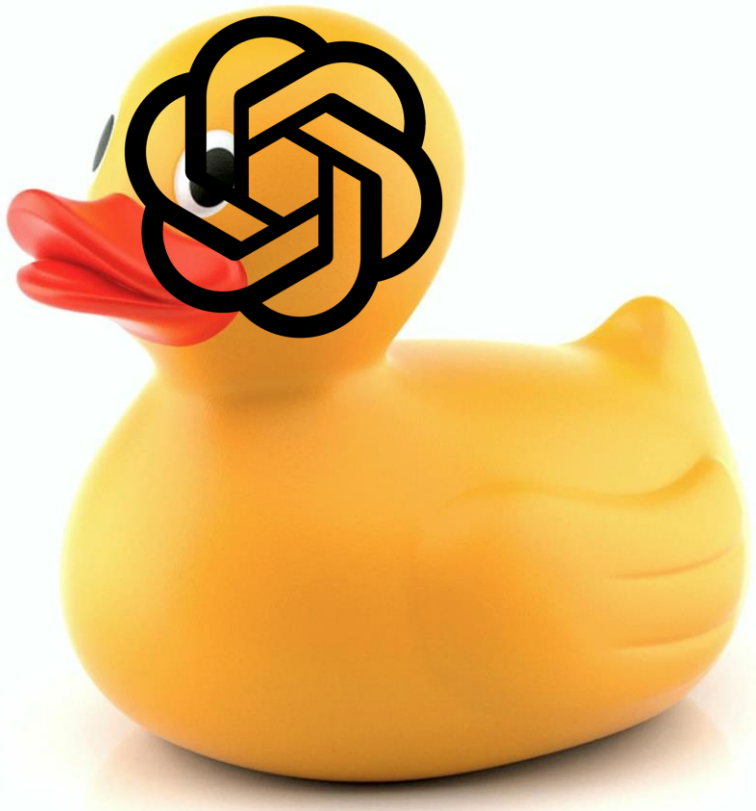
- **Artificial Intelligence…**



Extra Credit Activity 1: Calculator

- Jupyter Notebooks / IPython Notebooks
- Demo

Assignments (***pmr_02_exercises.ipynb***)

- **If not** finished:
  - Assignment #1: Performing Arithmetic Operations using Python
  - Assignment #2: Variables and Data Types in Python
- **else:**
  - Assignment #3: Branching using Conditional Statements and Loops in Python
  - Assignment #4: Functions and scope

…and then “Extra Credit Activity 1: Calculator”