Python: the Language

Python Introduction	Datatypes and Variables
Lists and loops	Selection
Functions	Organise code & IO

Python Introduction

- The philosophy of Python
    - Programming is not only easy to write but also easy to read.
- Python is *simple* and *small*.
- Python is one of the most popular programming languages that has survived the test of time.

- Python is one of the three languages that students must master
  - Java (C#/C++) : Server/High-performance
  - Python: AI/LLM and SE
  - JavaScript: App development

Static and Dynamic Language

Program creation has two steps:

1. **Compilation** – translate source code into low-level code.
2. **Execution** – run the translated low-level code.

Compilation

- In this step, a static programming language such as Java or C# checks types to avoid errors.
    - Static languages have types.

```
// Java compiler (javac) finds an error at compile time
String hello = 123;
hello[10]; // This error is not possible
```

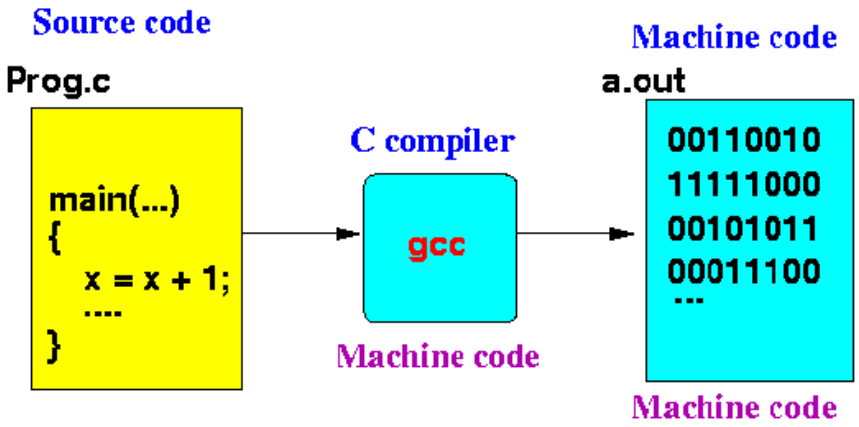
- Python (a Dynamic programming language) does not check types.
    - This may cause a serious bug that is hard to find.
    - The type bug will appear only when we run it.

```
hello = "hello"; hello = 40
hello[10] // This error will happen at runtime
```

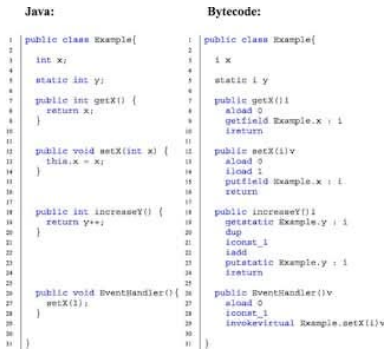
Byte code conversion

- In the compilation step, modern programming languages translate high-level code into low-level code.
    - Humans understand high-level code.
    - Machine understands low-level code.

- System programming languages, such as C/C++/Rust, compile high-level code directly to machine code.
- CPU can execute the machine code directly.



- Java or Python translates high-level code into bytecode.
- CPU cannot execute bytecode directly, so we need a VM (Virtual Machine).



Execution

- Java’s JVM uses JIT to compile bytecode to machine code during execution.
- Python executes bytecode line by line without compilation.
- Python runs 10–100 times slower than Java.

Python: Pros and Cons

Pros of Python

- Small and easy to learn.
- Fast compile time without type checking.
- Very high-level language.
- Short build-debug-rewrite cycle.
- Many packages and tools.

Cons of Python

- No type checking, so it's hard to find bugs.
- Type hinting is introduced and widely used.

```python
age: int = 20
name: str = "Alice"
is_active: bool = True

def greet(name: str) -> str:
    return f"Hello, {name}"
```

Slow execution time (No JIT)

- Mojo can be up to 35,000 times faster with direct machine code.
- PyPy is at least 7 times faster using JIT, no code changes.
- Python 3.13 adds experimental JIT support.

Datatypes and Variables

- Python has datatypes and variables.
- Python does not check types for variables.

```
# x can reference any time without checking
x = 10 # 10 is an int type value
x = "Hello" # "Hello" is a string type value
```

- A datatype (at a high level) is a set of specific values and their properties.
- The number 15 is an integer datatype, and the integer datatype has properties such as '+'.

- String datatype also has a `+' property, but the action differs (this is called Polymorphism).

```
x = 10; y = 20;
z = x + y # z = 30

a = "Hello"; b = "World";
c = a + b # c = "HelloWorld"
```

- We can use type() function to check the type name

```
type("Amsterdam") # -> <class 'str'>
type(1) # -> <class 'int'>
type([1,2,3]) # -> <class 'list'>
type({'a':10}) # -> <class 'dict'>
{type({1,2}) # -> <class 'set'>
type(true) # -> <class 'bool'>
```

Expression

A Python expression means computation.

- We can use the + symbol to add two values.
- We have other symbols such as -, *, /, '' to compute.

```
print(3 + 4)
print(3 - 4)
print(3 * 4)
print(3 / 4) # returns 0.75 (double type value)
print(3 // 4) # returns 0 (int type value)
print(10 + 20*4) # 90 as multiplication first
print((10+20)*4) # 120
```

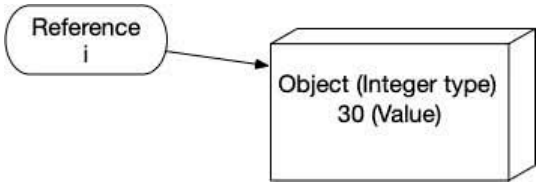
Variables

Python is pure OOP; everything is an object.

- No need for `new` to create objects.
- Python code is simple.

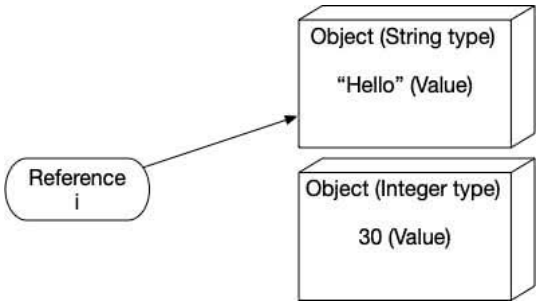
```
Integer i = new Integer(30); //Java
i = 30 // Python
```

- The Variables in Python are references.
- The value assignment is an instantiation and reference assignment.




```
i = int(30) # 30 is an it
i = 30 # same
```

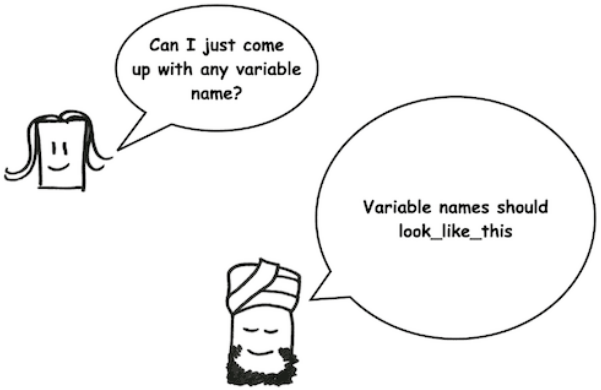
- In this example, 30 is an integer object, and variable i can reference any object freely.




```
i = 30
i = "Hello"
```

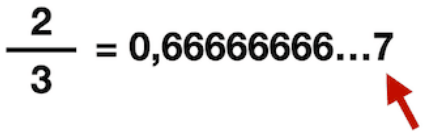
Naming rules

- Class starts with a capital letter.
- It should not start with a number or special characters
- No spaces; use _ instead.



Floating point number

- There is an infinite number of floating-point numbers.
- So, we approximate it.




```
>>> 1.2 + 1.0
2.2
>>> 1.2 - 1.0
0.19999999999999996 # surprise!
```

String format and interpolation

Python provides an f-string (format string).

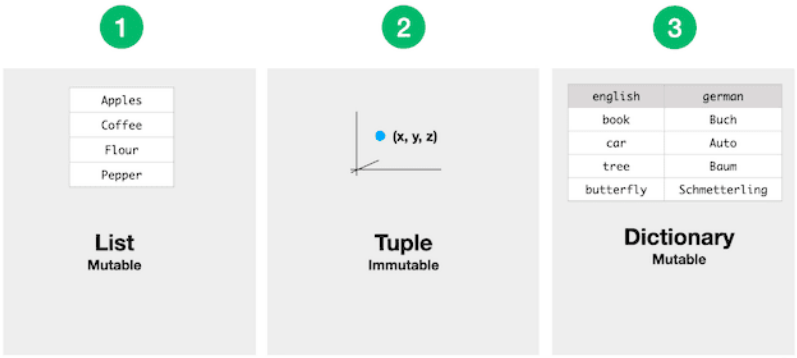
- It is a way of string interpolation (use an expression in a string).

```
name = "world"
print(f"Hello {name}") # prints out "Hello world")
print("Hello " + "world") # alternative solution
```

Lists and loops

Python has three lists.

- A list (mutable).
- A tuple (immutable).
- A dictionary (list with keys).



A List

- We can use the `[ ... ]` symbol or the `list` function to make a list.
- We use the `append` method to add an item to a list.

```
names = ["Vera", "Chuck", "Dave"]
names = list() # alternative solution
names.append("Vera"); ...
```

- We use an index to access a list.
- Python supports for-in-loop.

```
names = ["Vera", "Chuck", "Dave"]
print(names[0]) # "Vera"
for name in names:
  print(name)
```

- Python uses `len()` to get an array's size, not `names.length()`.
- This relies on duck typing: `len()` calls the list's hidden `__len__` method.

```
names = ["Vera", "Chuck", "Dave"]
len(names) # 3
names.__len__() # same as before
```

- Python has built-in functions, such as len() and print().
- There are many built-in functions.

		Built-in Functions		
abs()	delattr()	hash()	memoryview()	set()
all()	dict()	help()	min()	setattr()
any()	dir()	hex()	next()	slice()
ascii()	divmod()	id()	object()	sorted()
bin()	enumerate()	input()	oct()	staticmethod()
bool()	eval()	int()	open()	str()
breakpoint()	exec()	isinstance()	ord()	sum()
bytearray()	filter()	issubclass()	pow()	super()
bytes()	float()	iter()	print()	tuple()
callable()	format()	len()	property()	type()
chr()	frozenset()	list()	range()	vars()
classmethod()	getattr()	locals()	repr()	zip()

Tuples

- Tuples are immutable lists.
- Created with the `()`, accessed with the `[]` operator.

```
x = (1,2, 'a')
# AttributeError:
# 'tuple' object has no attribute 'append'
x.append(4)
print(x[0])
```

- Tuples have a `__len__` method, so the built-in `len()` function works on them thanks to duck typing.

```
x = (1,2, 'a')
print(len(x)) # 3
x.__len__() # 3
```

Dictionary

- A Python dictionary is a key/value pair.
- Created with `{...}`.

```
x = {'a':10, 'b':20}
print(x['a'])
x.update({'c':30})
for i in x: print(i) # print keys
for i in x: print(x[i]) # print values
```

- Behind the scenes, a list is a dictionary with keys as an index.

```
x = [1,2,3]
x = {0:1, 1:2, 2:3}
```

- The `in` operator checks if a key is in the dictionary.

```
x = {'a':10}
if 'b' in x: x['b'] += 20 # update the value
else  x['b'] = 20 # create a new
```

Selection

- Relational Expression
- If statement

Relational Expression

- Python has relational operators: >, <, ==, !=, >=, <=.
- Logical operators 'and', 'or', 'not' combine expressions.

```
5 > 4  # True
5 > 4 and 5 > 6  # False
```

- Python uses == to compare strings (checks value equality).

```
"Jim" == "Sam"  # Like Java's .equals()
```

If Statement

- Python does not have a switch/case statement.
- Python supports only if statements

```
if x == 3: print("x is 3")
elif x == 4: print("x is 4")
else: print("Not")
```

If expression

- Python supports if expressions.

```
x = 3 if value == 10 else 20 # python
x = value == 10 ? 3 : 20;  // Java
```

Functions

Python supports functions.

- Define a function with `def`, a name, parameters in parentheses, and a body.
- Use `return` to send back a value from the function.

- We can call the function by giving arguments that match the parameters.

```
def add(x, y):
  return (x + y)
print(add(1,2))

def add(x = 1, y = 2): # default argument
  return (x + y)
print(add()) # same
```

Nested Functions

- Python supports nested functions (functions in a function).

```
def complex_add(x,y):
  def add(x, y): return (x + y)
  return add(x,y) + add(x,y)
complex_add(1,2) # add(1,2) + add(1,2) -> 1+2+1+2
complex_add(y=2, x=1)
```

Closure

- Nested functions can access variables from their outer function—this is called a closure.
- Closures let inner functions use those variables even after the outer function ends.

```
def outer():
    message = "Hello, world!"
    def inner():
        print(message)
    return inner

greet = outer()
greet()  # Output: Hello, world!
```

- `inner` accesses `message` from `outer`, forming a closure.
- `greet` retains `message` even after `outer` ends.

Explode arguments

- Use `*` to unpack a list into positional arguments.
- Use `**` to unpack a dict into named arguments.

- Explode arguments make code simple and easy to read.

```
x = [1,2]
print(add(*x)) # add(1, 2)
y = {'x':10, 'y':20}
print(add(**y)) # add(x = 10, y = 20)
```

Organize code & IO

- File read/write
- Error Handling

File read/write

- We can use the open() method to open a file and read/write strings.

```
text = "Hello, this is a text file!"
file = open ("hello.txt", "w") # "w" for write
file.write(text)
file.close()

file = open ("hello.txt", "r")
for str in file.readlines(): # read all lines in a string
  print(str)
```

Error Handling

- When we make errors in coding, and Python detects them, it is a `compile-time error`.
- When an error occurs during the execution of the code, Python detects them: `run-time error` or `exceptions`.

```
print("Hell" # Compile time error

file = open ("hello2.txt", "r")
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
FileNotFoundError: [Errno 2] No such file or directory: 'hello2.txt'
```

A runtime error or exception is worse than a compile-time error:

- It is harder to fix.
- Users find the bug, not the software engineer.

- Use `try/except` to handle runtime errors in Python.
- Use `with/as` to automatically manage resources and ensure cleanup, like closing files, even if exceptions occur.

```
try:
  file = open ("hello2.txt", "r")
except FileNotFoundError as e:
  print(f"{e}!!!")

with open("hello2.txt", "r") as f:
  f.readlines()
```