

Functions



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Objectives

Specific Objectives

- Understanding functions in Python

Source

- <https://docs.python.org/3/reference/>
- Charles R. Severance (www.pythonlearn.com)
- <https://ellibrodepython.com/>
- Python Tutorial - Tapa blanda. Guido Van Rossum (2012)

Outline

- **Introduction**
- Conversions
- Function components
- Value vs Reference
- Multiple parameters
- Nested functions
- Annotations
- Lambda functions
- Decorators

Introduction

- There are two kinds of functions in Python
 - Built-in functions that are provided as part of Python - `raw_input()`, `type()`, `float()`, `max()`, `min()`, `int()`, ...
 - Functions (user defined) that we define ourselves and then use them
- We treat the built-in function names like reserved words (i.e. we avoid them as variable names)
- Functions are **objects**, then you can store them in data structures

Introduction

- Since functions are objects, it means that they can be:
 - Assigned to variables
 - Passed as arguments to other functions
 - Returned from functions
- Functions in Python have attributes. Common built-in attributes :
 - `__name__`: The name of the function
 - `__doc__`: The function's docstring
 - `__module__`: The module in which the function is defined

Introduction (I)

- Functions in Python are objects and ultimately inherit from the base class 'object'

Functions are objects

```
def mi_funcion():  
    pass
```

```
print(type(mi_funcion))  # <class 'function'>  
print(isinstance(mi_funcion, object))  # True
```

We know already

- A function is some reusable code that takes arguments(s) as input does some computation and then returns a result(s)
- We define a function using the *def* reserved word
 - We indent the body of the function
 - This defines the function but does not execute the body of the function
- We call/invoke the function by using the function name, parenthesis and arguments in an expression

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Type Conversions

- When you put an integer and floating point in an expression the integer is implicitly converted to a float
- You can control this with the built in functions `int()` and `float()`

Type Conversions

Example:

```
print (float(99) / 100) # Output: 0.99
```

```
i = 42
```

```
type(i) # Output: <type 'int'>
```

```
f = float(i) # print f -- Output: 42.0
```

```
type(f) # Output: <type 'float'>
```

```
a = 1 + 2 * float(3) / 4 - 5 # Output: -2.5
```

String Conversions

Example:

```
sval = '123'

type(sval)  #<type 'str'>

#print(sval + 1)  #Error

ival = int(sval)

type(ival)  # <type 'int'>

print (ival + 1)  # Output: 124

nsv = 'hello bob'

#niv = int(nsv)  #Error, no numeric characters
```

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Arguments

- An argument is a value we pass into the function as its input when we call the function
- We use arguments so we can direct the function to do different kinds of work when we call it at different times
- We put the argument in parenthesis after the name of the function

Example:

```
Message = max ("my message")
```

```
#"my message" is the argument
```

```
#max is the name of the function
```

Parameters

- It is a variable which we use in the function definition
- It is a “handle” that allows the code in the function to access the arguments for a particular function invocation

Parameters

Example: Parameters

```
def greet(lang):  
  
    if lang == 'es':  
        print ('Hola')  
  
    elif lang == 'fr':  
        print ('Bonjour')  
  
    else:  
        print ('Hello')
```

Example: Arguments

```
greet('en')    #Hello  
  
greet('es')    #Hola  
  
greet('fr')    # Bonjour
```

Return Values

- It will often take its arguments, do some computation and return a value to be used as the value of the function call in the calling expression
- The ***return*** keyword is used for this

Example:

```
def greater(num):  
  
    if num >= 0:  
  
        return True  
  
    else:  
  
        return False
```

Example:

```
print (greater (10))    # True  
  
print (greater (-10))   # False
```


Multiple Parameters/Arguments Values

- A function can take multiple parameters to perform operations

Example:

```
def add_numbers(a, b, c):  
    return a + b + c  
  
result = add_numbers(1, 2, 3)  
  
print(result)  # Output: 6
```

Returning Multiple Values

- Python allows functions to return multiple values at once
- This feature enhances code readability and efficiency
- Method 1: using tuples

Multiple Return Values

- A function can return multiple values:

Example: Returning

```
def get_person_info():  
  
    name = "John Doe"  
  
    age = 30  
  
    city = "New York"  
  
    return name, age, city
```

Example: Calling

```
name, age, city = get_person_info()  
  
print(name)    # Output: John Doe  
  
print(age)     # Output: 30  
  
print(city)    # Output: New York
```

Returning Multiple Values: Tuples

Example: Tuples

```
def get_coordinates():  
  
    x = 10  
  
    y = 20  
  
    return x, y  
  
coordinates = get_coordinates()  
  
print(coordinates)  # Output: (10, 20)  
  
print(f"x: {x}, y: {y}")  # Output: x: 10, y: 20
```

Returning Multiple Values: List

Example: List

```
def get_fibonacci(n):  
  
    fib = [0, 1]  
  
    for i in range(2, n):  
  
        fib.append(fib[i-1] + fib[i-2])  
  
    return fib  
  
fibonacci_sequence = get_fibonacci(10)  
  
print(f"First 10 Fibonacci numbers: {fibonacci_sequence}")
```

Returning Multiple Values: Dictionary

Example: Dictionary

```
def get_movie_info():  
  
    return {  
  
        "title": "La habitación de al lado",  
  
        "director": "Almodovar",  
  
        "year": 2024,  
  
        "rating": 9.2  
  
    }  
  
movie = get_movie_info()  
  
print(f"{movie['title']} ({movie['year']}) directed by {movie['director']}")
```

Returning Multiple Values: Class

Example: Class

```
class Rectangle:

    def __init__(self, width, height):

        self.width = width

        self.height = height

def get_rectangle():

    return Rectangle(10, 5)

rect = get_rectangle()

print(f"Rectangle: width={rect.width}, height={rect.height}")
```

Void Functions

- A function that does not return any value
- It performs an action but does not return a result to the caller
- They do not use the return statement to return a value
- They perform an action such as printing, modifying global variables, or writing to a file
- If no return statement is used, they implicitly return None

Example:

```
def greet(lang):  
    if lang == 'es':  
        print ('Hola')  
    elif lang == 'fr':  
        print ('Bonjour')  
    else:  
        print ('Hello')
```


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Value vs Reference

- Value: is the actual data stored in a variable
- Reference: is the address or location in memory where the data is stored
- In Python, **variables are references** to objects in memory.
- This means when you assign a variable, you are assigning a reference to an object, not the actual value

Immutable vs. Mutable Types

- Immutable Types:
 - Definition: objects that cannot be changed after they are created
 - Examples: int, float, str, tuple
 - Behavior: when an immutable object is modified, a new object is created
- Mutable Types:
 - Definition: objects that can be changed after they are created
 - Examples: list, dict, set
 - Behavior: when a mutable object is modified, the original object is changed

Immutable Types (Pass by Value)

- When passed to a function, a copy of the reference is made
- Rebinding the reference inside the function does not affect the original object
- Result: The original variable remains unchanged

Example: immutable: int, float, str, tuple

```
x = 10
```

```
def funcion(entrada):
```

```
    entrada = 0
```

```
funcion(x)
```

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

Mutable Types (Pass by Reference)

- When passed to a function, a reference to the object is passed
- Modifying the object inside the function affects the original object
- Result: The original list `x` is modified

Example: mutable: list, dict, set

```
x = [10, 20, 30]

def function(entrada):

    entrada.append(40)

function(x)

print(x)  # Output: [10, 20, 30, 40]
```

Rebinding vs. Modifying Mutable Objects

- Rebinding “entr” to a new list does not change the original list x
- The reference “entr” now points to a new list, but x still points to the original list
- Result: The original list x remains unchanged

Example: Rebinding a mutable object

```
x = [10, 20, 30]

def function(entr):

    entr = []

function(x)

print(x)  # Output: [10, 20, 30]
```

Using id() to Understand References (I)

- The id() function returns a unique id for the object

Example: Different objects

```
x = 10
```

```
print(id(x)) # Example Output: 4349704528
```

```
def funcion(ent):
```

```
    entrada = 0
```

```
    print(id(ent)) # Example Output: 4349704208
```

```
funcion(x)
```

Using id() to Understand References (II)

Example: The same object

```
x = [10, 20, 30]
```

```
print(id(x)) # Example Output: 4422423560
```

```
def funcion(entrada):
```

```
    entrada.append(40)
```

```
    print(id(entrada)) # Example Output: 4422423560
```

```
funcion(x)
```


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Multiple Parameters with *args

- Use *args to pass a variable number of non-keyword arguments to a function
- non-keyword arguments = argumentos posicionales
- “*” means to pack them in a **tuple**
- Useful when you don't know the number of arguments to the function
- The name “args” is a convection, you can change it

Multiple Parameters with *args

Example I: *args

```
def test_var_args(f_arg, *args):  
    print("primer argumento normal:", f_arg)  
  
    for arg in args:  
        print("argumentos de *argv:", arg)  
  
test_var_args('python', 'foo', 'bar')
```

Output

```
primer argumento normal: python  
  
argumentos de *argv: foo  
  
argumentos de *argv: bar
```

Multiple Parameters with *args (I)

Example II: *args

```
def print_numbers(*args):  
    for number in args:  
        print(number)  
  
print_numbers(1, 2, 3, 4, 5) # Output: 1\n 2 \n 3\n 4\n 5\n
```

Multiple Parameters with `**kwargs`

- Use `**kwargs` to pass a variable number of keyword arguments to a function
- Key arguments = argumentos con nombre o de palabras clave
- `**` means to pack the arguments in a dictionary
- The name “kwargs” is a convection, you can change it

Multiple Parameters with ****kwargs**

Example I: ****kwargs**

```
def print_info(**kwargs):  
    for key, value in kwargs.items():  
        print(f"{key}: {value}")  
  
print_info(name="John", age=30, city="New York")  
  
# Output: # name: John\n age: 30\n city: New York\n
```

Multiple Parameters with `**kwargs` (I)

Example II: `**kwargs`

```
def saludame(**kwargs):  
    for key, value in kwargs.items():  
        print("{0} = {1}".format(key, value))
```

```
saludame(nombre="Covadonga")
```

```
#Output: nombre = Covadonga
```

Combining *arg and **kwargs

- Let's consider this example:

Example I: Combining

```
def test_args_kwargs(arg1, arg2, arg3):  
  
    print("arg1:", arg1)  
  
    print("arg2:", arg2)  
  
    print("arg3:", arg3)
```


Combining *args and **kwargs (I)

Example I: Combining

```
#With *args
```

```
args = ("dos", 3, 5)
```

```
test_args_kwargs(*args)
```

```
#output: arg1: dos \n arg2: 3 \n  arg3: 5  \n
```

```
# With **kwargs:
```

```
kwargs = {"arg3": 3, "arg2": "dos", "arg1": 5}
```

```
test_args_kwargs(**kwargs)
```

```
#Output: arg1: 5 \n arg2: dos \n arg3: 3
```

Combining *args and **kwargs (II)

Example II: Combining

```
def print_details(*args, **kwargs):  
    for arg in args:  
        print(arg)  
  
    for key, value in kwargs.items():  
        print(f"{key}: {value}")  
  
print_details(1, 2, 3, name="John", age=30, city="New York")
```

Combining *args and **kwargs (III)

Example III: Combining

```
def funcion_mixta(*args, **kwargs):
```

```
    print("args:", args)
```

```
    print("kwargs:", kwargs)
```

```
funcion_mixta(1, 2, 3, a=4, b=5)
```

```
# Salida:
```

```
# args: (1, 2, 3)
```

```
# kwargs: {'a': 4, 'b': 5}
```

Combining all parameters

- If you want to use all three types of input arguments to a function: normal, `*args`, and `**kwargs`, you must do so in the following order:

```
Function_name(fargs, *args, **kwargs)
```

Unpacking

Example: Unpacking

```
def saludar(nombre, edad):  
    print(f"Hola, {nombre}. Tienes {edad} años.")  
  
datos = ["Alice", 30]  
  
info = {"nombre": "Bob", "edad": 25}  
  
saludar(*datos)  # Desempaqueta la lista  
  
saludar(**info)  # Desempaqueta el diccionario
```

Exercise:

- Crear una función calculadora que reciba un número variable de argumentos posicionales y de nombre
- La función debe realizar una operación sobre los números recibidos, basada en el argumento con nombre operacion, que puede ser "suma", "multiplicacion", "resta", o "division"
 1. Define la función calculadora(*args, **kwargs)
 2. Usa el valor del argumento con nombre (e.g. operacion="multiplicacion") para decidir qué operación realizar
 3. Si no se especifica operacion, realiza la suma de los números

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Nested functions

- You can make your functions nested
- Purpose:
 - Encapsulation: helps to hide the inner function from the outside world
 - Code Organization: breaks down complex tasks into simpler, smaller functions

Nested functions

Example: Nested Function

```
def outer_function(text):  
    def inner_function():  
        print(text)  
    inner_function()  
outer_function("Hello, World!")  
  
# Output: Hello, World!
```

Nested functions with Return Value

Example: Nested Function

```
def outer_function(x):  
    def inner_function(y):  
        return x + y  
    return inner_function  
  
adder = outer_function(10)  
  
print(adder(5))  # Output: 15
```

Exercise:

- Crea una función: *crear_multiplicador(factor)* que reciba un número *factor* como argumento
- Defina una función interna llamada *multiplicar(numero)* que multiplique *numero* por *factor*
- Retorne la función interna *multiplicar()*
- Luego, usa la función *crear_multiplicador()* para:
 1. Crear una función llamada *duplicar* que duplique cualquier número que se le pase
 2. Crear una función llamada *triplicar* que triplique cualquier número que se le pase

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Annotations

- A way of associating arbitrary metadata with function arguments and return values
- Purpose:
 - Provide additional information about the types and purposes of function arguments and return values
 - Improve code readability and support type hinting

Example: Annotations

```
def function_name(arg1: annotation1, arg2: annotation2) -> return_annotation:  
  
    pass
```

Accessing Annotations

- Function annotations can be accessed using the `__annotations__` attribute
- The output is a dictionary where keys are parameter names and values are the annotations

Example: Annotations

```
def greet(name: str, age: int) -> str:

    return f"Hello, {name}. You are {age} years old."

print(greet.__annotations__)

# Output: {'name': <class 'str'>, 'age': <class 'int'>, 'return': <class 'str'>}
```

Combined with Default Values

Example: Annotations

```
def greet(name: str = "World") -> str:
```

```
    return f"Hello, {name}!"
```

```
def filtrar_pares(salida: list = []) -> list:
```

```
    return [i for i in salida if i % 2 == 0]
```

```
print(filtrar_pares([1, 2, 3, 4, 5, 6])) # Output: [2, 4, 6]
```

```
greet() # Output: Hello, World!
```

Customize Annotations

Example: Annotations – Custom Class

```
class ClassA:

    pass

def function(a: ClassA) -> ClassA:

    return a

a = ClaseA()

function(a)
```


Example to try

- Python uses dynamic typing
- Annotations help specify expected types but do not enforce them

Example: Annotations – No error

```
# suma.py

def suma(a: int, b: int) -> int:

    return a + b

print(suma(7.0, 3))    #output 10
```

Static Checking

- Static Type Checking with *mypy*

Example: Annotations – Static type checking

```
$pip install mypy
```

```
$pip install typing
```

```
((base) MacBook-Pro-de-Maria-2:pythonProjects mariadr-moreno$ mypy suma.py
suma.py:5: error: Argument 1 to "suma" has incompatible type "float"; expected "int"  [arg-type]
Found 1 error in 1 file (checked 1 source file)
(base) MacBook-Pro-de-Maria-2:pythonProjects mariadr-moreno$ █
```

Dynamic Checking

- Dynamic Type Checking with *isinstance*

Example: Annotations – Dynamic type checking

```
def add1(a: int, b: int) -> int:

    if not isinstance(a, int) or not isinstance(b, int):

        print(f"Arguments must be integers, got {type(a).__name__} and {type(b).__name__}")

    else:

        return a + b

print(add1(7.0, 3))
```

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Lambda Functions

- Also known as anonymous functions
- Small, one-line functions without a name
- Defined using the 'lambda' keyword
- Can have any number of arguments, but only one expression

Why Use Lambda Functions?

- Concise way to create simple functions
- Useful for short, one-time use functions
- Can make code more readable in certain situations
- Can only contain expressions, not statements (e.g. cannot loops or if)
- Limited to a single expression
- Can be less readable for complex operations
- Debugging can be more difficult due to lack of a name

Lambda

Example: Lambda Function

```
# Regular function

def square(x):

    return x ** 2

# Equivalent lambda function

square_lambda = lambda x: x ** 2

print(square(4))          # Output: 16

print(square_lambda(4))  # Output: 16
```

Example: Lambda with Multiple Arguments

Regular function

```
def multiply(x, y):
```

```
    return x * y
```

Equivalent lambda function

```
multiply_lambda = lambda x, y: x * y
```

```
print(multiply(3, 4))          # Output: 12
```

```
print(multiply_lambda(3, 4))  # Output: 12
```


Example: Lambda with conditional expressions

```
# Lambda function with a conditional expression
```

```
max_lambda = lambda a, b: a if a > b else b
```

```
print(max_lambda(5, 3)) # Output: 5
```

```
print(max_lambda(2, 7)) # Output: 7
```

map function

- Returns a map object that we can convert to list or tuple

```
map  
map(function, objeto iterable)
```

map function

Example

```
def cuadrado(numero):  
    return numero * numero  
  
lista = [1, 2, 3, 4, 5]  
resultado = map(cuadrado, lista)  
  
lista_resultado = list(resultado)  
print(lista_resultado) #Output: [1, 4, 9, 16, 25]
```

Exercise

- Usa lambda y map() para convertir una lista de temperaturas de grados Celsius a Fahrenheit
 - $Fahrenheit = (grados\ centígrados \times 9/5) + 32$

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Decorators

- Decorators are a powerful way to modify or extend the behavior of functions or classes without changing their source code
- They are functions that take another function (or class) as an argument and return a new, modified function (or class)
- Syntax: @decorator_name
- Lambda functions do not allow the use of decorator syntax

Mission

- Adding functionality to existing functions or methods
- Modifying the behavior of functions or classes
- Logging function calls
- Measuring execution time
- Verifying permissions or authentication
- And many other uses...

Example: Decorator

```
def my_decorator(function):  
    def wrapper():  
        print("Before calling the function")  
        function()  
        print("After calling the function")  
    return wrapper  
  
@my_decorator  
  
def greet():  
    print("Hello!")  
  
greet()
```

```
Before calling the function  
Hello!  
After calling the function
```


Example: Decorator with arguments

```
def repeat(times):  
    def decorator(function):  
        def wrapper(*args, **kwargs):  
            for _ in range(times):  
                result = function(*args, **kwargs)  
            return result  
        return wrapper  
    return decorator  
  
@repeat(3)  
def greet(name):  
    print(f"Hello, {name}")  
  
greet("Alice")
```

```
Hello, Alice  
Hello, Alice  
Hello, Alice
```

Example I: Decorator for a tasks

```
def medir_tiempo(func):  
  
    def wrapper(*args, **kwargs):  
  
        inicio = time.time()  
  
        resultado = func(*args, **kwargs)  
  
        fin = time.time()  
  
        print(f"La función {func.__name__} tomó {fin - inicio:.4f} segundos.")  
  
        return resultado  
  
    return wrapper  
  
@medir_tiempo  
  
def calcular_suma(n):  
  
    return sum(range(n))
```

Call the function

Ejemplo de uso

```
print(calcular_suma(1000000))
```

Example: Class Decorators

```
def singleton(cls):  
  
    instances = {}  
  
    def get_instance(*args, **kwargs):  
  
        if cls not in instances:  
  
            instances[cls] = cls(*args, **kwargs)  
  
        return instances[cls]  
  
    return get_instance  
  
@singleton  
  
class Database:  
  
    def __init__(self):  
  
        print("Initializing the database")
```

Example: Class Decorators

```
db1 = Database()  
  
# Prints: Initializing the database  
  
db2 = Database() # Prints nothing,  
uses the same instance  
  
print(db1 is db2) # Prints: True
```

Exercise...

- Create a decorator called `log_event` that will add a timestamp to the function call and print the function name along with its arguments. It will contain a nested function called “wrapper”
- Create lambda functions for different types of events (e.g., `user_login`, `data_update`, `error_occurred`)
- Use `*args` and `**kwargs` in your decorator (*wrapper* function) to handle any number of positional and keyword arguments
- Apply the decorator to the lambda functions and test them with various inputs
- Use *import time*

...Exercise

```
def log_event(func):  
    pass  
    # Create lambda functions for events  
    user_login = lambda username: f"User {username} logged in"  
    #...  
    # Apply decorator to lambda functions  
    logged_user_login = log_event(user_login)  
    #....  
    # Try the functions  
    logged_user_login("Alice")  
    logged_data_update("user_count", 42)  
    logged_error_occurred(404, "Page not found")
```