COMP 1023 Introduction to Python Programming

Functions (Part I)

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Introduction

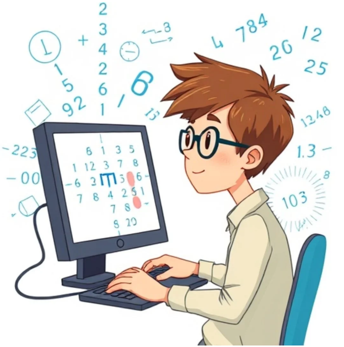
- Suppose that we need to find the sum of integers from 1 to 10, from 20 to 37, and from 35 to 49.

```python
# Filename: sum_of_integers.py
def main():
    total = 0
    for i in range(1, 11):
        total += i
    print("Sum of integers from 1 to 10 is", total)
    total = 0
    for i in range(20, 38):
        total += i
    print("Sum of integers from 20 to 37 is", total)
    total = 0
    for i in range(35, 50):
        total += i
    print("Sum of integers from 35 to 49 is", total)

if __name__ == "__main__":
    main()
```

Observations

The code for computing these sums is very similar, except that the starting and ending integers are different.



Introduction

- It is better to write commonly used code once and then reuse it.
- In Python and other programming languages, we can do this by defining a function, which enables us to create reusable code.
- For example, the preceding code can be simplified by using functions, as follows:

```python
# Filename: sum_of_integers_func.py
def sum_range(i1, i2):
    result = 0
    for i in range(i1, i2 + 1):
        result += i
    return result

def main():
    print("Sum of integers from 1 to 10 is", sum_range(1, 10))
    print("Sum of integers from 20 to 37 is", sum_range(20, 37))
    print("Sum of integers from 35 to 49 is", sum_range(35, 49))

if __name__ == "__main__":
    main()
```

Functions

- A function is a collection of statements grouped together that performs an operation. For example, `input("Enter a value ")` is a function.

Syntax

```
def <function_name>(<parameter_list>):
    <statement_1>
    <statement_2>
    ...
    <statement_N>
```

where `<function_name>` is the name of the function, `<parameter_list>` is a list of parameters (i.e., a number of variables), and `<statement_1>`, ..., `<statement_N>` denote the program statements that need to be executed when the function is called/invoked.

- Now, you should notice that 'main' is actually a function, which serves as the entry point of a program.

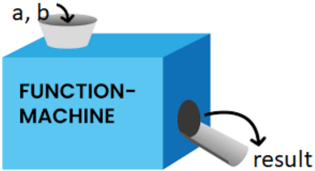
Analogy of Python Functions: The Machine Model

- Think of a Python function as a machine that performs specific tasks.
- The function accepts inputs, processes them, and produces outputs:
  - Inputs: These are the arguments or parameters you provide to the function, similar to raw materials fed into a machine.
  - Processing: The function executes a series of operations on the inputs, akin to the machine performing its designated tasks.
  - Outputs: The result produced by the function after processing, comparable to the finished product that comes out of the machine.
- Example:

```
# Filename: add_numbers.py

def add(a, b):
    return a + b    # The machine adds two numbers and
                    # returns the result

result = add(5, 3)  # Inputs: 5 and 3; Output: 8
```



Terminologies

```
# Filename: maximum_two_numbers.py

# Define a function
def max(num1, num2):
    if num1 > num2:
        result = num1
    else:
        result = num2
    return result

def main():
    x, y = 10, 20
    z = max(x, y)  # Call the function
    print("The larger number is", z)

if __name__ == "__main__":
    main()
```

Output:

```
The larger number is 20
```

- Function name: max
- Formal parameters: num1 and num2
- Parameter list: num1, num2
- Function header: `def max(num1, num2)`
- Function body: The function body implements the logic of the function.
- Where does the function return a value? The return statement returns the value, i.e., `return result`
- Function caller of max: `main()`
- Actual parameters (or arguments): x and y

Type Hinting in Functions

- Recall, type hinting allows you to specify the expected data types of parameters (now function parameters). You can also specify what is the expected types of return values.
- It enhances code readability and helps with static type checking.

```
def max(num1: int, num2: int) -> int:
    if num1 > num2:
        result = num1
    else:
        result = num2
    return result
```

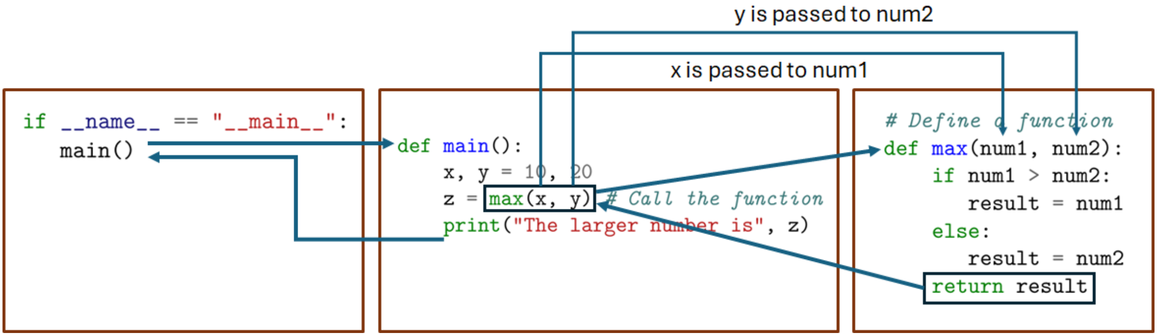
Syntax

- Use a colon (:) to annotate parameter types.
- Use an arrow (->) to annotate the return type.

Benefits of Type Hinting

- Improves code clarity and documentation.
- Facilitates easier debugging and maintenance.

Program Flow



```
if __name__ == "__main__":
    main()
```

```
def main():
    x, y = 10, 20
    z = max(x, y) # Call the function
    print("The larger number is", z)
```

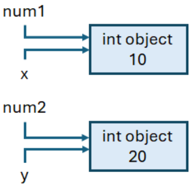
```
# Define a function
def max(num1, num2):
    if num1 > num2:
        result = num1
    else:
        result = num2
    return result
```

- When a function is called/invoked, control is transferred to the function.
- When the function is finished, control is returned to the point where the function was called.

Parameter Passing

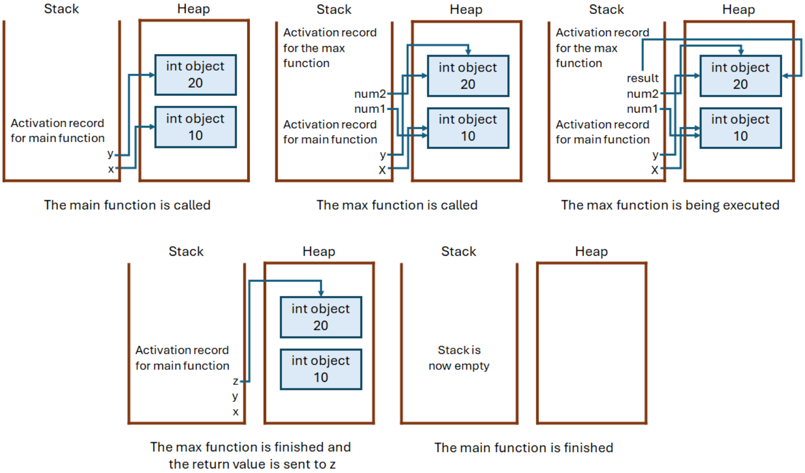
```python
# Define a function
def max(num1, num2):
    if num1 > num2:
        result = num1
    else:
        result = num2
    return result
```

```python
def main():
    x, y = 10, 20
    z = max(x, y) # Call the function
    print("The larger number is", z)
```



- Variable *x* references an integer object with the value 10. Passing *x* to *num*1 is actually passing the reference of the object to *num*1, so *x* and *num*1 point to the same object if value does not change.
- Similarly, variable *y* references an integer object with the value 20. Passing *y* to *num*2 is actually passing the reference of the object to *num*2, so *y* and *num*2 point to the same object if value does not change.

Activation Records



Stack
Heap
int object 20
int object 10
Activation record for main function
y
x

The main function is called

Stack
Heap
Activation record for the max function
num2
num1
int object 20
int object 10
Activation record for main function
y
x

The max function is called

Stack
Heap
Activation record for the max function
result
num2
num1
int object 20
int object 10
Activation record for main function
y
x

The max function is being executed

Stack
Heap
int object 20
int object 10
Activation record for main function
z
y
x

The max function is finished and the return value is sent to z

Stack
Heap
Stack is now empty

The main function is finished

- Activation records (or stack frames) are used to store information about active functions.
- They contain details such as function parameters, local variables, and return addresses.
- Each time a function is called, a new activation record is created on the call stack.

None Function

- Technically, every function in Python returns a value, whether you use a return statement or not.
- If a function does not return a value, by default, it returns a special value, `None`.
- A function that does not return a value is called a None function or a void function.
- A return statement is not needed for a None/void function, but it can be used to terminate the function and return control to the caller. The syntax is `return` or `return None`.

```python
def sum(number1, number2):
    total = number1 + number2
    # No return statement

def main():
    print(sum(1, 2))  # Print None

if __name__ == "__main__":
    main()
```

```python
def sum(number1, number2):
    total = number1 + number2
    return  # Explicitly returning None
            # Alternaive: return None
def main():
    print(sum(1, 2))  # Print None

if __name__ == "__main__":
    main()
```

Ordering of the Functions

- In the last example, ‘main‘ is defined after ‘max‘. Can ‘main‘ be defined before ‘max‘? Yes! In Python, functions can be defined in any order in a .py file, as a function is loaded into memory when it is called.

```python
# max function before main
def max(num1, num2):
    if num1 > num2:
        result = num1
    else:
        result = num2
    return result

def main():
    x, y = 10, 20
    z = max(x, y)  # Call the function
    print("The larger number is", z)

if __name__ == "__main__":
    main()
```

```python
# main function before max
def main():
    x, y = 10, 20
    z = max(x, y)  # Call the function
    print("The larger number is", z)

def max(num1, num2):
    if num1 > num2:
        result = num1
    else:
        result = num2
    return result

if __name__ == "__main__":
    main()
```

Positional and Keyword Arguments

- When calling a function, we need to pass arguments to the formal parameters.
- There are two kinds of arguments: positional arguments and keyword arguments.
- Using positional arguments requires that the arguments be passed in the same order as their respective parameters in the function header.
- We can also call a function using keyword arguments, passing each argument in the form `name = value`.

```python
# Filename: print_n_times.py
def print_n_times(text, n):
    for i in range(n):
        print(text)

def main():
    # Pass "COMP 1023" to text, and 3 to n
    print_n_times("COMP 1023", 3)  # Print COMP 1023 3 times
    # Can we do print_n_times(3, "COMP 1023")? ...
    # Pass 3 to n, and "COMP 1023" to text
    print_n_times(n = 3, text = "COMP 1023")  # Print COMP 1023 3 times

if __name__ == "__main__": main()
```

Output:

```
COMP 1023
COMP 1023
COMP 1023
COMP 1023
COMP 1023
COMP 1023
```

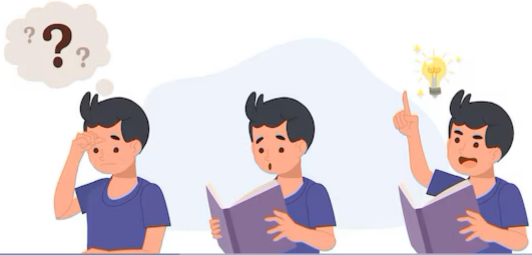
Positional and Keyword Arguments

- It is possible to mix positional arguments with keyword arguments, but positional arguments cannot appear after any keyword arguments.

```
# Filename: sum.py
def sum(value1, value2, value3):
    return value1 + value2 + value3

def main():
    print(sum(10, value2 = 20, value3 = 30))  # Print 60
    print(sum(10, value2 = 20, 30))  # Error: positional argument follows keyword argument

if __name__ == "__main__":
    main()
```



What do you observe?

```python
# Filename: increment.py
def increment(n):
    n += 1
    print("n inside the function is", n)

def main():
    x = 1
    print("Before the call, x is", x)
    increment(x)
    print("After the call, x is", x)

if __name__ == "__main__": main()
```

Output:

```
Before the call, x is 1
n inside the function is 2
After the call, x is 1
```

Observations

- Integers in Python are immutable. When you pass an integer to a function, you are passing a reference to the value, not the variable itself. Any modifications to the parameter inside the function do not affect the original variable outside the function.
- To modify the original variable, you would need to return the new value from the function and reassign it to the original variable, or use a mutable type (like a list or dictionary) to hold the value.

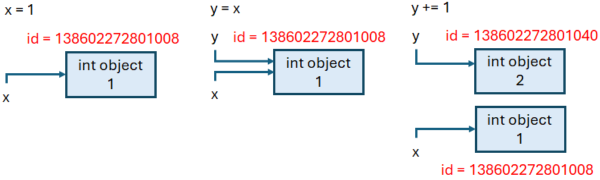
Immutable Objects

- Numbers are immutable objects. The content of immutable objects cannot be changed.
- Whenever we assign a new number to a variable, Python creates a new object for the new number and assigns the reference of the new object to the variable.

```
x = 1
y = x
print(id(x))  # The reference of x
print(id(y))  # The reference of y
y += 1
print(id(y))  # The reference of y
```

Output:

```
138602272801008
138602272801008
138602272801040
```



The id(object) function returns the unique id of an object.

Default Arguments

- Python allows you to define functions with default argument values.
- The default values are used for the parameters when a function is called without specific arguments.

```python
def print_area(width = 1, height = 2):  # Filename: print_area.py
    area = width * height
    # \t is an escape sequence that represents a tab character.
    print("Width:", width, "\theight:", height, "\tarea:", area)

def main():
    print_area()                      # Default arguments with width = 1, height = 2
    print_area(4, 2.5)                # Positional arguments with width = 4, height = 2.5
    print_area(height = 5, width = 3) # Keyword arguments
    print_area(10)                    # Positional argument with width = 10, height = 2
    print_area(width = 1.2)           # Keyword argument with width = 1.2, default height = 2
    print_area(height = 6.2)          # Keyword argument with height = 6.2, default width = 1

if __name__ == "__main__":
    main()
```

Default Arguments

Output:

```
Width: 1       height: 2       area: 2
Width: 4       height: 2.5     area: 10.0
Width: 3       height: 5       area: 15
Width: 10      height: 2       area: 20
Width: 1.2     height: 2       area: 2.4
Width: 1       height: 6.2     area: 6.2
```

Returning Multiple Values

- Python allows a function to return multiple values.
- The function, sort, takes two numbers and returns them in ascending order.

```python
# Filename: sort_numbers.py
def sort(number1, number2):
    if number1 < number2:
        return number1, number2
    else:
        return number2, number1

def main():
    n1, n2 = sort(3, 2)
    print("n1 is", n1)
    print("n2 is", n2)

if __name__ == "__main__":
    main()
```

Output:

```
n1 is 2
n2 is 3
```

- The values returned by the sort function are packed into a tuple.
- This tuple can be unpacked directly into multiple variables, making it convenient to work with multiple return values.

pass Statement

- The pass statement is a null operation. When it is executed, nothing happens.
- It is used as a placeholder where syntactically some code is required, but no action is needed.
- Uses of the pass statement:
  - Empty function bodies
  - Empty classes (to be discussed later)
  - Selection/branching statements
  - Looping/iterative statements

Uses of pass Statement

- Empty function bodies: When defining a function, Python requires some code within the function block. If you don't have any idea yet, you can use pass to avoid syntax errors.

```
def my_function():
    pass
```

- Empty classes: Similar to functions, classes in Python also need a body. You can use pass to create an empty class. (We will talk more about this later.)

```
class MyClass:
    pass
```

- Selection/branching statements: In if, elif, or else blocks, if you want to do nothing under certain conditions, pass can be used.

```
x = 5
if x > 10:
   pass  # No action if x > 10
else:
   print("x is not greater than 10")
```

- Looping/iterative statements: Similarly, in loops, you can use pass if you intend to do nothing within the loop under specific conditions.

```
for i in range(5):
    if i == 3:
       pass  # Skip action when i is 3
    else:
       print(i)
```

Key Terms

- actual parameter
- argument
- caller
- default argument
- formal parameter (i.e., parameter)
- function
- function header
- immutable objects
- keyword arguments
- local variable
- None
- None function
- parameter
- positional arguments
- return value
- void function

Review Questions

Fill in the blanks in each of the following sentences about the Python environment.

1. A function header begins with the ________________ keyword followed by the ________________ and its ________________, and ends with a colon.
2. A function is called a ________________ if it does not return a value.
3. A ________________ statement can also be used in a void function for terminating the function and returning to the function's caller.
4. The ________________ that are passed to a function should have the same ________________, ________________, and ________________ as the parameters in the function header if no default values or keywords specified.

Answer: 1. def; function's name; parameters, 2. void function, 3. return, 4. arguments; number; type; order.

Review Questions

Fill in the blanks in each of the following sentences about the Python environment.

5. A function's arguments can be passed as ________________ or ________________.
6. Python allows you to define functions with ________________. The ________________ are passed to the parameters when a function is invoked without the arguments.
7. The Python return statement can return ________________.

Answer: 5. positional arguments; keyword arguments, 6. default argument values; default values, 7. multiple values

Further Reading

- Read Chapter 6 of “Introduction to Python Programming and Data Structures” textbook.

That's all!

Any questions?