Information, Computation, Communication
Learning Python

Functions – Part I

Agenda

- Why functions?
  - Example: Intersection of two lists
- Function definition
  - def, arguments, body, return
- Calling functions
  - Example: multiply and add
- Function arguments, continued
- Type-dependent behavior
- Program flow with functions
- Local function variables
  - Example: bubble sort

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Why Functions?

Why Functions?

- Group lines of code in a way that allows reuse without repetition
  - **Maximize code reuse**
  - **Improve code readability**
- Avoid copy-paste (code repetition)
  - **Minimize code redundancy**
  - Minimize the number of **error sources**
- Test code once, and then reuse it as frequently as needed to perform computations on **various** data
  - **Good code maintainability**
- In some programming languages, functions are referred to as subroutines or procedures

Example: Intersection Of Two Lists

- Write a code that finds all elements shared between input lists **seq1** and **seq2** and creates a new list containing only those elements, sorted in increasing order

```
result = []  # Initialize an empty list to store the intersection.
for x in seq1:  # Iterate over each item in the first sequence.
    if x in seq2:  # Check if the item is also in the second sequence.
        if not x in result:
            result.append(x)  # If so, add it to the result list.
result.sort()  # Sort the resulting list to ensure items are in order.
```

Example: Intersection Of Two Lists

- Write a **function** that finds all elements shared between input lists **seq1** and **seq2** and returns a new list containing only those elements, sorted in increasing order

```
def seq_intersect(seq1, seq2):
    result = []  # Initialize an empty list to store the intersection.
    for x in seq1:  # Iterate over each item in the first sequence.
        if x in seq2:  # Check if the item is also in the second sequence.
            if not x in result:
                result.append(x)  # If so, add it to the result list.
    result.sort()  # Sort the resulting list to ensure items are in order.
    return result  # Return the sorted intersection list.
```

Function Definition

Before it can be used, a function must be defined

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Function Definition

General format and syntax:

```
def name(arg1, arg2, …, argN):
    code
    return result
```

Function Definition: def Statement

```
def name(arg1, arg2, …, argN):
    code
    return result
```

- **def** keyword creates a function (object) and assigns to it a function **name**
  - Choose a name that best describes what the function does
  - PEP 8 Style Guide recommends:
    - Function names should be lowercase, with words separated by underscores as necessary to improve readability

Function Definition: Parameters (Arguments)

```
def name(arg1, arg2, …, argN):
    code
    return result
```

- The function name is followed by **parentheses**, grouping zero or more function **parameters**
- Parentheses are followed by a **colon**
- Parameters are variables (with **names** and **values**) acting as **inputs** to the function
  - Function code uses those variables to perform computation
- Parameters **connect** the function with the program that uses it

Function Definition: Function Body

- …is simply the code inside the function

```
def name(arg1, arg2, …, argN):
    code # function body
    return result
```

Function Definition: return Statement

```
def name(arg1, arg2, …, argN):
    code # function body
    return result
```

- **return** keyword permits the function to answer with a value it obtained for the given set of arguments
- We say that the **function returns a value**
- Return is **not mandatory**
  - Function anyway terminates when it reaches the last line of its body
  - If no return is specified, the function returns **None**
    - The None keyword is used to define a null value or no value at all

Calling Functions

To make use of a function, we call it

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Example: `multiply_and_add_scalar` function

- Consider the example function below, which multiplies two variables and sums the result with the third variable

```
# Start by function definition
def multiply_and_add_scalar(m, n, p):
    return m * n + p
```

- The function receives three arguments: m, n, and p. Therefore when called, this function expects three values. Then, it performs the computation on them and returns the result.

A Complete Script, Including Function Calls

```python
# Start by function definition
def multiply_and_add_scalar(m, n, p):
    return m * n + p

# Having defined it, we can now use the function (call it)
# m = 3, n = 4, p = 2
# Let us save the function result in variable t
t = multiply_and_add_scalar(3, 4, 2) # t = 14

# m = 5, n = 2, p = t (= 14)
t = multiply_and_add_scalar(5, 2, t) # t = 24
```

Function Arguments, Continued…

```
def multiply_and_add_scalar(m, n, p):
    return m * n + p
```

- In the previous example

```
t = multiply_and_add_scalar(3, 4, 2)
```

arguments were assigned by **their position**

- 1st position, value 3, was assigned to the 1st argument: m
- 2nd position, value 4, was assigned to 2nd argument: n
- 3rd position, value 2, was assigned to the 3rd argument: p

Function Arguments, Continued...

```
def multiply_and_add_scalar(m, n, p):
    return m * n + p
```

- In Python, arguments can also be assigned **explicitly**

```
multiply_and_add_scalar(m=3, n=4, p=2)
```

- When explicitly assigned, the order becomes irrelevant
- Examples of calls equivalent to the one above
  - `multiply_and_add_scalar(p=2, n=4, m=3)`, or
  - `multiply_and_add_scalar(n=4, p=2, m=3)`, etc.

Function Arguments, Continued…

- Python allows setting **default** values to parameters
- Default values are used if no other value is specified

```
def name(arg1=default_value1, arg2=default_value2, …, argN=default_valueN):
    code # function body
    return result
```

- **Note:** Parameters without default arguments cannot follow parameters with default arguments, because the positional assignment would fail to assign arguments correctly

Example: multiply_and_add_scalar function

```
# Start by function definition
def multiply_and_add(m, n=0.5, p=2):
    return m * n + p

# m = 3, n = 0.5 (default), p = 2 (default)
t = multiply_and_add_scalar(3) # t = 3.5
# m = 5, n = 2, p = 2 (default)
t = multiply_and_add_scalar(5, 2) # t = 12
# Below call throws an error, as m has no value
t = multiply_and_add_scalar()
```

Type-Dependent Behavior

- In Python, the meaning of every expression depends completely upon the types of its objects
- This type-dependent behavior is called **polymorphism**
- Why does this matter?
  - The output of your function **may change** depending on the type of values (arguments) it was given

What is the output of this code?

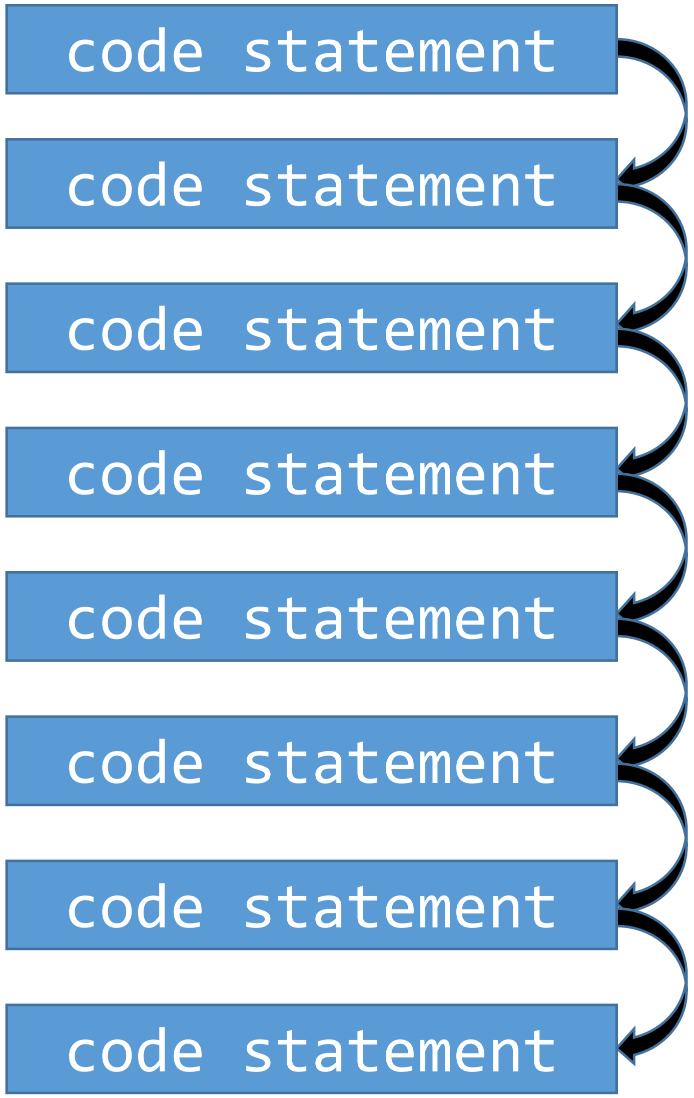
```
def multiply_and_add(m, n, p):
    return m * n + p

# Note the nested function call
t = multiply_and_add("I", 1, multiply_and_add("C", 2, "-P"))
print(t)



# Answer: ICC-P
# first, multiply_and_add("C", 2, "-P") returns "CC-P"
# then, multiply_and_add("I", 1, "CC-P") returns "ICC-P"
```

Program Flow

With functions

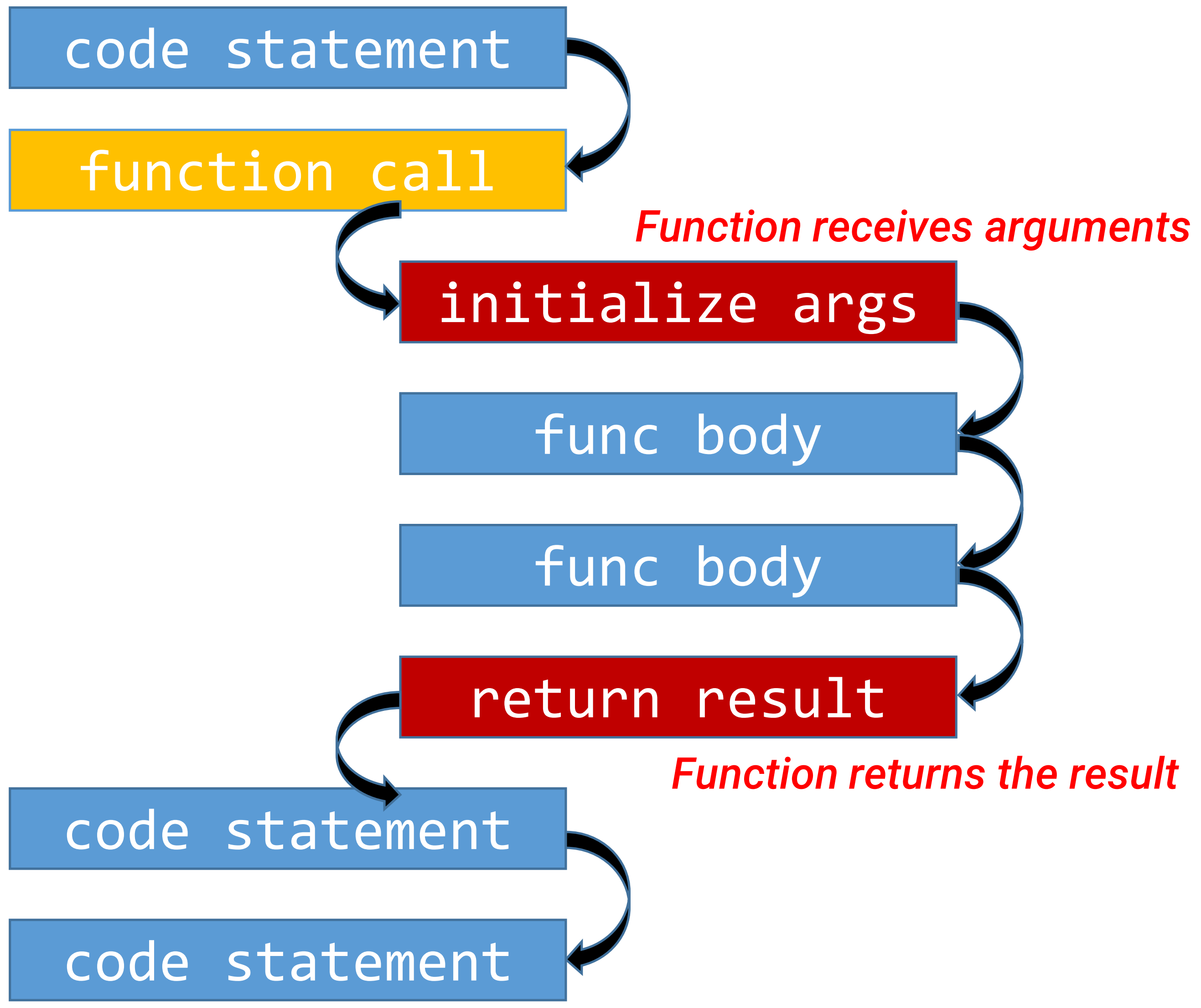
Program Flow

Without functions



Program Flow

With functions



Local Function Variables

- Functions can have their variables
- A variable is **local** if it is created in the function body
  - Function **parameters** are considered **local** variables
- Local variables are **created** when the function is **called** and **destroyed** when the function **terminates**
- We say that *"local variables live inside the function"* or their **scope** is *"local to the function"*
- Code that called the function cannot access (neither to read nor to write to) function local variables
  - Consequently, function local variables can have any name, and they will not be mistaken for variables used outside of the function

Example: Bubble Sort

Write a function **bubble_sort_descending( )** which takes a list of numbers as argument and returns the list sorted in descending order

[Wiki] Bubble sort is a simple sorting algorithm that repeatedly steps through the input list element by element, comparing the current element with the one after it and swapping the values if needed. The process repeats until the list is sorted.

Bubble Sort Descending: Step by Step

- **Initial Step**
  - Start with an unsorted list of elements
  - The algorithm examines each pair of adjacent elements
- **Comparison and Swap**
  - For each adjacent pair, if the first element is smaller than the second, swap them;
    If not, leave them as is
  - This way, the smallest unsorted element "bubbles" up to the end of the list with each pass
- **Repeat Passes**
  - After one pass, the smallest element will be in its correct position at the end
  - Repeat the process for the remaining **unsorted** part of the list, which keeps shrinking as more elements are placed in their final positions
- **Completion**
  - Continue repeating the passes until no swaps are left to do, at which point the list is sorted

Example: Bubble Sort

```
def bubble_sort_descending(arr):
    n = len(arr) # local variable
    for i in range(n): # repeat for every array element; local var. i
        for j in range(0, n - i - 1): # traverse the unsorted part of the list
            if arr[j] < arr[j + 1]: # compare and swap
                temp = arr[j] # local variables temp and j
                arr[j] = arr[j+1]
                arr[j+1] = temp
    return arr # return the sorted array

# Example usage
seq = [5, 3, 8, 4, 2]
sorted_seq = bubble_sort_descending(seq)
print("Sorted array in decreasing order:", sorted_seq) # [8, 5, 4, 3, 2]
```

Next topic:
Recursive Functions