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Python For Computational Problem Solving (UE22CS151A)

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Functions are the building blocks of almost every Python program. They're where the real action takes place!

In your Python Basics journey, you've probably encountered functions such as print(), len(), and round(). These are all built-in functions because they come built into the Python language itself. You can also create user-defined functions that perform specific tasks.

Functions break code into smaller chunks and are great for defining actions that a program will execute several times throughout your code. Instead of writing the same code each time the program needs to perform the same task, just call the function!

User defined function:

A function is a self-contained block of code that performs a specific task. Functions ideally take input, performs a set of operations and returns an output to the program that invoked it.

A function is a named piece of code. We write a sequence of Python code and then give a name to it. We can then refer and run the whole code by using its name.

Why do we use this concept of function? When do we use this?

• A function is expected to do one and only thing. We call such a function cohesive. Because it has a clearly defined aim, the code will be small, neat and clean.

• Similar functionality is normally required at number of places. If we write a function, then we can call or invoke the function without rewriting or copying the code. It makes the user's program more readable.

• If the code of the function has to be changed for whatever reason – make it more efficient, make it more flexible – we have to do at only one place. Thus it helps in maintenance.

• Once tested, the function can be used with total assurance. There is no necessity of debugging the code repeatedly.

Summary:

We use functions for the following reasons:

- Supports modularity
- Promotes reuse of code
- Enhances readability

- Debugging and maintainance becomes easier

Types of functions:

1. Built in – existing functions
2. User defined – defined by user

Built in functions

Built-in Functions			
A abs() aiter() all() any() anext() 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__()

Each of these built-in functions performs a specific task. The code that accomplishes the task is defined somewhere, but you don't need to know where or even how the code works. All you need to know about is the function's interface:

- What arguments (if any) it takes
- What values (if any) it returns

Then you call the function and pass the appropriate arguments. Program execution goes off to the designated body of code and does its useful thing. When the function is finished, execution returns to your code where it left off. The function may or may not return data for your code to use.

In [3]:
```
# Examples of builtin functions
l=[6,2,5,4,1]
print(len(l))
print(max(l))
print(sorted(l))
```

```
5
6
[1, 2, 4, 5, 6]
```

Function Definition :

The usual syntax for defining a Python function is as follows:

```
def function_name([parameters]):
    statement(s)
```

A function definition has two parts – header(or leader) and suite.

- The header starts with the keyword def
- then the function name
  - function name is an identifier
- then a pair of parentheses
  - within the parentheses, we may have parameters
- then a colon
- then the suite follows – suite can have any valid statement of Python including another function definition!

Function call :

The syntax for calling a Python function is as follows:

function_name([arguments])

arguments are the values passed into the function. They correspond to the parameters in the Python function definition. You can define a function that doesn't take any arguments, but the parentheses are still required.

Example of a function definition and call

Run the program under Python tutor to understand how the function definition and function call are processed.

Example of function definition and invocation

In [16]:

```
def foo():                  #
    print("I am foo")       # function definition
    return                  #

print("one")
foo()          # function call: Name of the function followed by parentheses causes a f
print("two")
```

```
one
I am foo
two
```

In [ ]:

```
print("one")
foo()          # NameError: name 'foo' is not defined
print("two")   # Function_definition should precede function_call

def foo():                  #
    print("I am foo")       # function definition
    return                  #
```

Processing of Function Definition:

Name of the function followed by parentheses causes a function call – this results in transfer of control to the leader of the function and then the suite is executed – after that the control comes back to the point after the function call in the user's code. A few more things happen when the function call is mapped to the function leader. We shall discuss them later.

In our example, leader of function foo is processed first and the function entity with the name foo is created. The suite of foo is not processed at this point. print("one") is called displaying the string one. Then foo is called – transferring control to the leader of foo – then the suite of foo is executed resulting in display of the string I am foo. Then the control is returned. Then print is called displaying the string two.

Note: Processing of function definition demo with http://pythontutor.com/

Function Definition and Function Name – internals:

Let us examine the below code to understand two things.

- What does the function name stand for?
- What happens when the function is defined?

In [17]:

```
# foo : is a function; therefore callable

def foo():
    print("I am foo")

print(foo)
print("one")

'''
The function name below (without parenthesis) like a variable name is
an expression. Any expression on a line is also a statement.
But it does not cause a function call.
'''
foo # no function call
print("two")

'''
Statement below is like a variable assignment. Both foo and bar refer
to the function entity called foo. The reference count of the function
entity goes up by 1 and in this case, becomes 2.
'''
bar = foo # bar also becomes callable
print(bar)

# both give the same output
foo()
bar()

# remove foo
del foo    # The del keyword is used to delete objects.
bar()      # still works!
```

```
<function foo at 0x000002C7D80A0940>
one
two
<function foo at 0x000002C7D80A0940>
I am foo
I am foo
I am foo
```

When the function is defined, the function name becomes an interface for us to refer to the function. The function entity is stored with the name used in the definition along with the suite. Whatever is stored with the function entity remains unchanged until no name refers to it. Each entity in Python has a reference count. It is equally true of the function entity.

foo # no function call

This above statement does not result in a function call. The function name like a variable name is an expression. Any expression on a line is also a statement. But it does not cause a function call. To invoke a function, we do require the function call operator - a pair of parentheses.

bar = foo

This is like a variable assignment. Both foo and bar refer to the function entity called foo. The reference count of the function entity goes up by 1 and in this case, becomes 2.

If we display either bar or foo, we get the same output as both refer to the same function entity foo.

We can invoke the function either by using the name foo or bar. We say that both are callable. A callable is the name of a defined function or a variable holding the function name.

del foo

This statement causes the name foo to be removed and the reference count of the function entity foo to be decremented. As bar still refers to the same function entity, the reference count would not be zero. Therefore the function entity foo remains and can be called using the name bar.

bar() # still works!

Function call: arguments and parameters:

A function does some task for us. It requires some values to operator on. We provide them when calling a function. We put these within parentheses in the function call. We call them arguments. The arguments are always expressions. They should have some value.

add(4,5)

In the function definition, we specify variables which receive these arguments. These are called parameters. The parameters are always variables.

def add(x,y): return(x+y)

When the function call is made, the control is transferred to the function definition. The arguments are evaluated and copied to the corresponding parameters. This is called parameter passing by value or call by value.

In [10]:
```
def add(x,y):      # The parameters are always variables.
    return x+y     #    Parameters do not have any fixed type.
                   #    So, we say that the types are generic.

result1=add(4,5.5) # The arguments are always expressions. They should have some value.
print(result1)     #    When the function call is made, The arguments are evaluated
                   #    and copied to the corresponding parameters.
a=[1,2,3]; b=[4,5]
result2=add(a,b)
print(result2)

result3=add('Computer ','Science')
print(result3)
```

```
9.5
[1, 2, 3, 4, 5]
Computer Science
```

In [35]:
```
import math

def hypotenuse(a, b):    # a, b : parameters; always variables
    print("In hypotenuse function:")
    h = math.sqrt(a * a + b * b) # can create variables within the function; local varia
    print(f"Hypotenuse of triangle with sides {a} and {b} is {h}")
    return

hypotenuse(5, 12)    #5,12 : arguments
hypotenuse(3, 4)

#hypotenuse(3, 4, 5) # TypeError: hypotenuse() takes 2 positional arguments but 3 were g
#hypotenuse(3) # TypeError: hypotenuse() missing 1 required positional argument: 'b'
```

```
In hypotenuse function:
Hypotenuse of triangle with sides 5 and 12 is 13.0
In hypotenuse function:
Hypotenuse of triangle with sides 3 and 4 is 5.0
```

Number of arguments should match the number of parameters

hypotenuse(3, 4, 5) # error

hypotenuse(3) # error

The above example shows how to compute hypotenuse given the two limbs of a right angled triangle. In this example the arguments are constants – they can be any type of expression in general. The corresponding parameters are always variables.

In Python, parameters do not have any fixed type. So, we say that the types are generic.

When the function call is made, an activation record is created which will have

- Parameters
- local variables
  - Variables created within the suite of the function
- return address
  - Location to which the control of the program should be transferred once the function terminates
- temporary variables
  - unnamed variables required by the translator
- return value
  - value to be passed back to the caller

At the end of the function execution, when the control returns to the calling program, the activation record is deleted and cannot be accessed again.

If we want to access a value that was calculated within the function, we must ensure to return it to the calling program explicitly.

If we call the function again in the program, a new activation is created for that instance of the function execution

In [8]:
```
# Lets examine, using Pythontutor
def area_rect(x,y) :
    a=x*y
    return a
a=area_rect(5,6)
print("Area of rectanle =",a)
```

```
Area of rectanle = 30
```

Demonstration of activation records creation (in Stack) during function calls.

In [2]:
```python
# Demonstrate using pythontutor

def sum(x,y,z):
    r3=x+y+z
    return r3

def avg(a,b,c):
    r2=sum(a,b,c)/3
    return r2

# Find the average of three numbers
m=25; n=35; o=45

r1=avg(m,n,o)
print(f'The average of {m},{n} and {o} is {r1}')
```

```
The average of 25,35 and 45 is 35.0
```

return statement

A return statement in a python function serves two purposes:

1. It immediately terminates the function and passes execution control back to the caller.
2. It provides a mechanism by which the function can pass data back to the caller.

In [1]:
```python
# Example 1:
import math

# A function by default returns nothing - called None in Python
def hyp(a, b) :
    h = math.sqrt(a * a + b * b) #local to the fn
    print(f"Hypotenuse of triangle with sides {a} and {b} is {h}")

res = hyp(3, 4)
#print("h : ", h) # not available here
print(res, type(res)) # None of NoneType
```

```
Hypotenuse of triangle with sides 3 and 4 is 5.0
None <class 'NoneType'>
```

In [11]:
```python
# Example 2:
def hyp1(a, b) :
    h = math.sqrt(a * a + b * b) # h is local to the fn
    return h  # returning data to the Caller

res = hyp1(3, 4)
print(res, type(res))
```

```
5.0 <class 'float'>
```

A called function(Callee) returns the control to the caller when

- the end of the function body is reached
- the return statement is executed.

The return statement is also used to return a value to the caller. The function does not specify a return type in its definition.

If you don't supply an explicit return statement with an explicit return value, then Python will supply an implicit return statement using None as a return value.

In the above Example-1, the function hyp, there is no return statement in the suite of the function. So, the caller is returned a notional value None of NoneType. This is similar to void functions of 'C'.

In the second case, the function hyp1 returns h as the result. The value of this expression(in this case, a variable) is returned to the caller.

What is the output?

In [61]:
```python
def fun():
    print('two')
    return
    print('three')
    return

print('one')
fun()
```

```
one
two
```

A function can return a value of any type. There is no restriction in Python.

Given two strings, find common letters.

In [14]:
```python
def find_common(str1, str2):
    commonchars_set = set(str1) & set(str2)
    res = ''
    for ch in commonchars_set:
        res += ch
    return res    # returning data to the Caller

s1 = "cattle"
s2 = "concat"
# expected output : c a t
print(f'Common letters in {s1} and {s2} :', find_common(s1, s2))
```

```
Common letters in cattle and concat : tca
```

In [22]:
```python
# Given two strings, find common letters.
def find_common(s1, s2):
    return set(s1) & set(s2)

s1 = "cattle"
s2 = "concat"
print(f'Common letters in {"cat"} and {"bat"} :', find_common("cat", "bat"))
print(f'Common letters in {s1} and {s2} :', find_common(s1, s2))
```

```
Common letters in cat and bat : {'t', 'a'}
Common letters in cattle and concat : {'t', 'c', 'a'}
```

Output the length of words in a given multi-word string.

In [64]:
```python
def disp_count(s):
    for word in s.split():
        print(f"len({word:^6}) -> {len(word)}")

disp_count("we are the world")
```

```
len(  we  ) -> 2
len( are  ) -> 3
len( the  ) -> 3
len(world ) -> 5
```

What would happen if we write statements after we have written a return statement?

Consider the following snippet of code

In [24]:
```
def example():
    print('an example function')
    return
    print('after return')   # Unreachable code

example()
```

```
an example function
```

In this function, the control returns as soon as the interpreter encounters the return statement, making the print statement after it an unreachable code.

Exercise Problems:

What is the output?

In [ ]:
```
def f1():
    print('Cool day')
    return f3()

def f3():
    return'chill'
    return'chill'    # Unreachable code

print(f1())
```

In [7]:
```
def largest_of_2(a,b):
    if a>b:
        return a
    else:
        return b

x=45
y=55
r=largest_of_2(x,y)
print(f'The largest of {x} and {y} is {r}')
```

```
The largest of 45 and 55 is 55
```

Returning Multiple Values

When we return a collection of values, the interpreter puts it together into a tuple and returns it to the calling program

In [9]:
```
def add():
    a = 12
    b = 13
    s = a+b
    return a,b,s   # becomes an unnamed tuple

sum = add()

print('type(sum) is',type(sum)) #type <class tuple>
print('sum =',sum)
```

```
type(sum) is <class 'tuple'>
sum = (12, 13, 25)
```

Arguments and Parameters:

Parameter passing:

Parameter passing by value: Copying the argument to parameter.

Argument passing in Python is somewhat of a hybrid between pass-by-value and pass-by-reference.

What gets passed to the function is a reference to an object, but the reference is passed by value.

The argument could be a simple or value type like int, float or it could be a structured type or reference type like list, dict.

Let us try some simple examples to understand this concept.

In [1]:
```python
def fn1(x):
    print('Inside function definition:')
    print('x =',x,'id(x) =',id(x))
    x = 10  # x is reassigned, but only one instance for the preallocated range -5 to 25
    print('x =',x,'id(x) =',id(x))

a = 10
print('Before function call:')
print('a =',a,'id(a) =',id(a))
fn1(a)
print('After function call:')
print('a =',a,'id(a) =',id(a))
```

```
Before function call:
a = 10 id(a) = 2706308557392
Inside function definition:
x = 10 id(x) = 2706308557392
x = 10 id(x) = 2706308557392
After function call:
a = 10 id(a) = 2706308557392
```

In [27]:
```python
def fn1(x):
    print('x =',x,'id(x) =',id(x))
    x += 10  # x=x+10, Integers are immutable, the reference is rebound, and the connect
             # Shorthand-assignment is assignment for immutable objects
    print('x =',x,'id(x) =',id(x))

a = 10
print('a =',a,'id(a) =',id(a))
fn1(a)
print('a =',a,'id(a) =',id(a))
```

```
a = 10 id(a) = 2638552394320
x = 10 id(x) = 2638552394320
x = 20 id(x) = 2638552394640
a = 10 id(a) = 2638552394320
```

In the above example. The parameter x which is a copy of the argument a is changed by doubling. The id of x is changed (due to x+=10). But the argument is not affected by the function call.

In [22]:
```python
def fn1(x):
    print('x =',x,'id(x) =',id(x))
    x = x + 10   # Integers are immutable. The reference is rebound, and the connection
    print('x =',x,'id(x) =',id(x))

a = 10
print('a =',a,'id(a) =',id(a))
fn1(a)
print('a =',a,'id(a) =',id(a))
```

```
a = 10 id(a) = 2638552394320
```

```
x = 10 id(x) = 2638552394320
x = 20 id(x) = 2638552394640
a = 10 id(a) = 2638552394320
```

The function fn1 is created. The variable a becomes 10. The function fn1 is called with the argument a whose value is 10. On the function call, the activation record of fn1 is created with the parameter x. The parameter x gets a copy of the argument a which is 10. The parameter is a local variable of the function fn1. It is changed to 20. When the end of the function is reached, the parameter is never copied to the corresponding argument. So, the variable a of the caller remains unchanged.

Note:

It is not possible to change an argument of a simple type by calling a function.

In [31]:
```python
def fn3(x):
    print('x =',x,'id(x) =',id(x))
    x = [33, 44]     # The reference is rebound, and the connection to the original objec
    print('x =',x,'id(x) =',id(x))

a = [11, 22]
print('a =',a,'id(a) =',id(a))
fn3(a)
print('a =',a,'id(a) =',id(a)) # [11, 22] ; no change
```

```
x = [11, 22]
x = [33, 44]
a = [11, 22]
```

The argument in the above program is a reference type. The argument a is copied to the parameter x. The id of x and id of a will be same. The elements of the list are not copied on this function call. But changing the parameter by assignment will create a new list breaking the relation of x with the list a. But the argument a is not affected.

In [23]:
```python
def fn3(x):
    print('x =',x,'id(x) =',id(x))
    x[1] = 55     # List is mutable. Changing list a
    x = [33, 44]  # The reference is rebound, and the connection to the original object
    #x[1] = 55
    print('x =',x,'id(x) =',id(x))

a = [11, 22]
print('a =',a,'id(a) =',id(a))
fn3(a)
print('a =',a,'id(a) =',id(a))
```

```
a = [11, 22] id(a) = 2638640288384
x = [11, 22] id(x) = 2638640288384
x = [33, 44] id(x) = 2638668972544
a = [11, 55] id(a) = 2638640288384
```

In [24]:
```python
def fn4(x):
    print('x =',x,'id(x) =',id(x))
    x = x + [33, 44]    # Not changing list a. Because of assignment,
                        #   the reference is rebound, and the connection
                        #   to the original object is lost.
    print('x =',x,'id(x) =',id(x))

a = [11, 22]
print('a =',a,'id(a) =',id(a))
fn4(a)
print('a =',a,'id(a) =',id(a))
```

```
a = [11, 22] id(a) = 2638669252416
```

```
x = [11, 22] id(x) = 2638669252416
x = [11, 22, 33, 44] id(x) = 2638640288384
a = [11, 22] id(a) = 2638669252416
```

In [25]:

```python
def fn4(x):
    print('x =',x,'id(x) =',id(x))
    x += [33, 44]     # changes a, because lists are mutable.
                      #  Here, shorthand-assignment is not assignment,
                      #  it is extending the same list
    print('x =',x,'id(x) =',id(x))

a = [11, 22]
print('a =',a,'id(a) =',id(a))
fn4(a)
print('a =',a,'id(a) =',id(a))
```

```
a = [11, 22] id(a) = 2638668972544
x = [11, 22] id(x) = 2638668972544
x = [11, 22, 33, 44] id(x) = 2638668972544
a = [11, 22, 33, 44] id(a) = 2638668972544
```

In [20]:

```python
def fn4(x):
    x += 'world'      # doesn't change a, because strings are immutable
    print('x =',x,'id(x) =',id(x))

a = 'Hello'
print('a =',a,'id(a) =',id(a))
fn4(a)
print('a =',a,'id(a) =',id(a))
```

```
a = Hello id(a) = 2638669113456
x = Helloworld id(x) = 2638669177456
a = Hello id(a) = 2638669113456
```

In [19]:

```python
def fn4(x):
    x.append(55)       # changes list a
    print('x =',x,'id(x) =',id(x))

a = [11, 22]
print('a =',a,'id(a) =',id(a))
fn4(a)
print('a =',a,'id(a) =',id(a))
```

```
a = [11, 22] id(a) = 2638668951936
x = [11, 22, 55] id(x) = 2638668951936
a = [11, 22, 55] id(a) = 2638668951936
```

As in the last case, both a and x will refer to the same list. When we append/extend to x, we are modifying what x refers to. So list a also gets changed.

In [11]:

```python
def fn5(x):
    print('x =',x,'id(x) =',id(x))
    x = x + " How are You?"
    print('x =',x,'id(x) =',id(x))

a = "Hello"
fn5(a)
print('a =',a,'id(a) =',id(a)) # Output is Hello
```

```
x = Hello id(x) = 2638640264816
x = Hello How are You? id(x) = 2638669232928
a = Hello id(a) = 2638640264816
```

In [18]:

```python
def fn5(x):
    print('x =',x,'id(x) =',id(x))
    x += " How are You?"    # Strings are immutable, new list is created by concatenatio
```

```
                                    # Shorthand-assignment is assignment for immutable objects
    print('x =',x,'id(x) =',id(x))

a = "Hello"
print('a =',a,'id(a) =',id(a))
fn5(a)
print('a =',a,'id(a) =',id(a))
```

```
a = Hello id(a) = 2638669179440
x = Hello id(x) = 2638669179440
x = Hello How are You? id(x) = 2638640135904
a = Hello id(a) = 2638669179440
```

Note:

- Modify a reference: others not affected
- Modify through a reference: others are affected

Summary 1:

From above examples, it is very clear that, changing the parameter of the reference type does not affect the argument.

The key takeaway here is that a Python function can't change the value of an argument by reassigning the corresponding parameter to something else.

Summary 2:

From above examples, it is very clear that, changing through the parameter will affect the argument.

Please check all these programs on the Python tutor. I suggest that you draw the schematics and understand how the parameter passing works.

Note:

Python's argument-passing mechanism has been called pass-by-assignment. This is because parameter names are bound to objects on function entry in Python, and assignment is also the process of binding a name to an object. You may also see the terms pass-by-object, pass-by-object-reference, or pass-by-sharing.

Argument Passing Summary

Argument passing in Python can be summarized as follows. Passing an immutable object, like an int, str, tuple, or frozenset, to a Python function acts like pass-by-value. The function can't modify the object in the calling environment.

Passing a mutable object such as a list, dict, or set acts somewhat—but not exactly—like pass-by-reference. The function can't reassign the object wholesale, but it can change items in place within the object, and these changes will be reflected in the calling environment.

Side Effects

So, in Python, it's possible for you to modify an argument from within a function so that the change is reflected in the calling environment. But should you do this? This is an example of what's referred to in programming lingo as a side effect.

More generally, a Python function is said to cause a side effect if it modifies its calling environment in any way. Changing the value of a function argument is just one of the possibilities.

Let us try to understand the consequence of this parameter passing mechanism with swapping concept

p, q = q, p

The above statement swaps variables p and q.

But the code below fails to swap the arguments no matter what type they are. The copies get swapped in the function but not the arguments!

In [30]:

```
def swap(p, q) :
    print('Inside function definition:')
    p, q = q, p       # only refernces are exchanged, not the values
    print('p =',p,'q =', q) # p and q are swapped

x, y = 11, 22
print('Before function call:')
print('x =',x,'y =', y)
swap(x, y)
print('After function call:')
print('x =',x,'y =', y) #does not swap
print()

print('Before function call:')
x, y = [11, 22], [33, 44]
print('x =',x,'y =', y)
swap(x, y)
print('After function call:')
print('x =',x,'y =', y) #does not swap
```

```
Before function call:
x = 11 y = 22
Inside function definition:
p = 22 q = 11
After function call:
x = 11 y = 22

Before function call:
x = [11, 22] y = [33, 44]
Inside function definition:
p = [33, 44] q = [11, 22]
After function call:
x = [11, 22] y = [33, 44]
```

Moral of this story: cannot write a (generic)function to swap variables in a language like python which does parameter passing by value.

Function Parameter and Types:

In [53]:

```
def fn1(a, b):   # The type of parameters a and b is generic
    print('type(a) =',type(a),' type(b) =',type(b))

fn1(10, 20)
fn1(True, "true")
fn1([11, 22], {33:44})

#fn1(1, 2, 3) # Error
#fn1(4) # Error
```

```
type(a) = <class 'int'>  type(b) = <class 'int'>
type(a) = <class 'bool'>  type(b) = <class 'str'>
type(a) = <class 'list'>  type(b) = <class 'dict'>
```

In python, the parameter has no specified type. The type is decided when the argument is copied on call to the function at runtime – type is determined dynamically.

Matching of arguments to parameters:

1. Positional Arguments

- match the argument to the parameter based on the position

2. Keyword or Named Arguments

- specify the parameter name in the function call
- match the argument based on the name of the parameter
- order of arguments does not matter

1) Positional arguments.

- In this case, we match the argument to the corresponding parameter.
- We match the first argument to the first parameter, the second argument to the second parameter, and so on from left to right.

In [12]:
```
def foo(a, b, c, d):
    print('a =',a,'b =',b,'c =',c,'d =',d)

foo(1, 2, 3, 4)
```

```
a = 1 b = 2 c = 3 d = 4
```

2) Keyword (or named) arguments

- In this case, we specify the name of the parameter and then symbol = and then the argument.
- In this case, the order of arguments does not have any effect and matching the argument to the parameter is based on the parameter_name=argument mentioned in the function call.
- The symbol = does not stand for assignment. As we know, assignment is not an expression and no variable is created in the environment of the caller.

In [14]:
```
def foo(a, b, c, d):
    print('a =',a,'b =',b,'c =',c,'d =',d)

foo(b = 2, d = 4, a = 1, c = 3)  # here b=2, c=3 ... are not assignment
                                 #  statements, they are just mapped/associated
```

```
a = 1 b = 2 c = 3 d = 4
```

We can also use a combination of these two techniques as long as we specify all the positional arguments before keyword arguments.

In [13]:
```
def foo(a, b, c, d):
    print('a =',a,'b =',b,'c =',c,'d =',d)

# specify all the positional arguments before keyword arguments
foo(1, 2, d = 4, c = 3)  # here d=4 and c=3 are not assignment statements, they are just
```

```
a = 1 b = 2 c = 3 d = 4
```

This feature makes the names of the parameters also an interface. As long as they have meaningful names, they will be calling the functions simple and less error prone.

Positional Arguments Specified by an Iterable

Positional arguments can also be passed to functions using an iterable object. Examples of iterable objects in Python include lists and tuples. The general syntax to use is:

function_name(*iterable)

Where function_name is the name of the function and iterable is the name of the iterable preceded by the asterisk * character.

An example of using a list to pass positional arguments to the complex() function is below. Note the asterisk * character is included before the term_list argument.

In [3]:
```
def foo(a, b, c, d):
    print(a, b, c, d)

l=[1,2,3,4]
foo(*l)     # foo(1,2,3,4)   # Here * is unpacking operator.

'''by using the * syntax, we're unpacking the values, which means that
the four elements list is unpacked, and the function is called with
four arguments 1,2,3 and 4'''
```

```
1 2 3 4
```

Out[3]:
```
"by using the * syntax, we're unpacking the values, which means that \nthe four elements
list is unpacked, and the function is called with \nfour arguments 1,2,3 and 4"
```

Positional-Only Arguments

In Python 3.8, you can use / to denote that all arguments before it must be specified by position.

In [9]:
```
def incr(x, /): # By adding / after x, you specify that x is a positional-only
                #  argument (i.e, parameter x is receiving vaule only
                #               from positional argument).
    return x + 1

incr(3.8)
#incr(x=3.8) # not allowed
```

Out[9]:
```
4.8
```

You can combine regular arguments with positional-only ones by placing the regular arguments after the slash:

In [8]:
```
def greet(name, /, greeting="Hello"): # here name is a positional-only argument
    return f"{greeting}, {name}"

greet("Christopher")

#greet("Christopher", greeting="Awesome job")
```

Out[8]:
```
'Hello, Christopher'
```

In greet(), the slash is placed between name and greeting. This means that name is a positional-only argument, while greeting is a regular argument that can be passed either by position or by keyword.

The benefit of using positional-only arguments is that you can more easily refactor your functions. In particular, you can change the name of your parameters without worrying that other code depends on those names.

In [ ]:
```
# Example 1:
def foo(p1, p2, /): # This means all functional arguments are positional.
```

```
        pass
```

In [2]:
```
# Example 2:

def foo(a, b, / , x, y):
    print("a snd b are positional: ", a, b)
    print("x and y are positional or keyword: ", x, y)
    print()
```

Here in the above function definition parameters a and b are positional-only, while x or y can be either positional or keyword.

Following function calls are valid (for example 2)

In [4]:
```
foo(40, 20, 99, 39)
foo(40, 3.14, "Hello", y="World")
foo(1.45, 3.14, x="Hello", y="World")
```

```
a snd b are positional:  40 20
x and y are positional or keyword:  99 39

a snd b are positional:  40 3.14
x and y are positional or keyword:  Hello World

a snd b are positional:  1.45 3.14
x and y are positional or keyword:  Hello World
```

But, following function call is not valid which raises an exception TypeError since a, b are not passed as positional arguments instead passed as keyword

In [ ]:
```
def foo(a, b, / , x, y):
    print("a snd b are positional: ", a, b)
    print("x and y are positional or keyword: ", x, y)

foo(a=1.45, b=3.14, x=1, y=4) # not valid call
```

keyword-only arguments

- Positional-only arguments nicely complement keyword-only arguments.
- In any version of Python 3, you can specify keyword-only arguments using the star (*).
- Any argument after * must be specified using a keyword:

In [16]:
```
def to_fahrenheit(*, celsius):
    return 32 + celsius * 9 / 5

#to_fahrenheit(40)
to_fahrenheit(celsius=40)
```

Out[16]:
```
104.0
```

Function Parameters: Default Parameters:

1. What does print method display at the end of the record?
2. What separator do we get between the fields?

We know that we get a newline and a space respectively by default. We also know that we can use keyword parameter and specify values for these two parameters in the call to the print function.

How do we specify the default parameter?

- Default Parameter can be associated with a value.
- If the argument is not provided for this parameter, then default value will be used.
- If the argument is provided for this parameter, then default value is not considered.
- Default value for a parameter is part of the function definition.

In [5]:
```
def multiply(a, b = 10):
    return a * b

print(multiply(10, 20))
print(multiply(30))
```

```
200
300
```

Note: The default parameter is part of the function definition. Only the rightmost parameters in the function definition can be default.

In [ ]:
```
def multiply(a, b = 10):
    return a * b
print(multiply(4, 5))
print(multiply(6))
```

- The function multiply can be called with one or two arguments.
- If the function is called with two arguments, the default parameter does not come into picture. The given argument is copied to b.
- If the function is called with one argument, then the default parameter 10 is copied to b before the execution of the function starts.

The default parameter is processed when the leader is processed and is stored as an attribute of the function definition and is not part of the activation record.

Default value being a variable in python

The default parameter can be a variable provided it is defined before the function definition.

In [11]:
```
x = 22

def foo(a = x) :
    print("foo : ", a)

x = 33 # this re-assignment to x will have no effect on the default
       #   stored in the function foo for a
foo(11) #11
foo() #22
```

```
foo :  11
foo :  22
```

So, in this case, a takes the present value of x which is 22. Change of x later will have no effect on the default parameter stored as an attribute of the function definition.

The behavior of the default appears to be unusual if the default parameter is of reference type. Let us examine the next example.

In [15]:
```
# parameters : default

def foo(x, a = []):
    a.append(x)
```

```
    print(a)

foo(10)  #[10]
foo(20)  #[10, 20]

z = [30, 40]
foo(50, z)       #[30, 40, 50]
foo(60)          # [10, 20, 60]
```

```
[10]
[10, 20]
[30, 40, 50]
[10, 20, 60]
```

def foo(x, a = []):

In the above leader statement the parameter has a default which is a list – a reference type. That reference will remain with the function entity. The default parameter is copied to a only if no argument is passed for a. if the list is changed, then that change will remain to persist and will manifest the next time the call is made without argument for a.

*args and **kwargs in Python

In Python, we can pass a variable number of arguments to a function using special symbols. There are two special symbols:

1) *args (Variable number of positional/Non-Keyword Arguments)

2) **kwargs (Variable number of Keyword Arguments)

1) *args (Variable number of Non-Keyword Arguments)

The special syntax *args in function definitions in python is used to pass a variable number of arguments to a function. It is used to pass a non-key worded, variable-length argument list.

Using the *, the parameter that we associate with the* becomes an iterable(i.e., tuple) meaning you can do things like iterate over it.

There are a few rules.

1) There can be only one such parameter in a function.

```
        def foo(*p, *q):   is an error
```

2) This(*args) follows all the positional parameters.

Note that args or arg is just a name. You're not required to use the name args. You can choose any name that you prefer.

In [6]:
```
def fn(x,y,*arg):          # Here * is unpacking operator.
    print(x,y,arg)

fn(1,2)
fn(1,2,3,4)
```

```
1 2 ()
1 2 (3, 4)
```

In [9]:
```
def fn(*arg,x,y) :
    print(arg,x,y)

#fn(1,2,3,4) # TypeError: fn() missing 2 required keyword-only arguments: 'x' and 'y'
fn(1,2,x=3,y=4)
```

```
(1, 2) 3 4
```

In [13]:
```
def my_sum(*integers):
    result = 0
    for x in integers:
        result += x
    return result

print(my_sum(1, 2, 3))

lst=[5,6,7,8]
print(my_sum(*lst))
```

```
6
26
```

The function still works, even if you pass the iterable object as integers instead of args. All that matters here is that you use the unpacking operator (*).

3) This parameter cannot be used as a keyword parameter.

We cannot specify the parameter name and give a tuple of arguments. The second example shows how to use variable parameter to find the smallest in number of arguments assuming that there is at least one argument.

Examples:

The full syntax of print() is:

print(*objects, sep=' ', end='\n', file=sys.stdout, flush=False)

- objects - object to the printed. * indicates that there may be more than one object
- sep - objects are separated by sep. Default value: ' '
- end - end is printed at last
- file - must be an object with write(string) method. If omitted it, sys.stdout will be used which prints objects on the screen.
- flush - If True, the stream is forcibly flushed. Default value: False

Example 1:

We use print() to display any number of arguments.

- print(1)
- print(1,2)
- print(1,2,3)

Example 2: Similarly if we wish to write a function which will examine an arbitrary number of strings, and returns the length of the longest string.

In this situation , it may not be possible to know ahead of time how many arguments we will be providing to the function. In such cases we can make use of Variable number of arguments.

In [14]:
```
def len_long(*s):
    max = 0
```

```
    print(s,type(s))
    for strgs in s:
        if len(strgs) > max:
            max = len(strgs)
    return max
x=len_long('narendraModi','RahulGandhi','AmitShah','Yogi')
print('The length of the longest string is',x)
```

```
('narendraModi', 'RahulGandhi', 'AmitShah', 'Yogi') <class 'tuple'>
The length of the longest string is 12
```

In [13]:

```
def f2(*args):
    print(args)
f2(5)
f2(10,"strings")
```

```
(5,)
(10, 'strings')
```

In [14]:

```
def f3(*args):
    print(args)
val=(5,6,7)
f3(val)   # equivalent to f3((5,6,7),) or f3((5,6,7))
f3(*val) # equivalent to f3(5,6,7)
```

```
((5, 6, 7),)
((5, 6, 7),)
(5, 6, 7)
```

2) **kwargs - Variable number of Keyword Arguments (key value pairs as arguments)

The special syntax **kwargs in function definitions is used to pass a keyworded, variable-length argument list.

We use the name kwargs with the double star. The reason is because the double star allows us to pass through keyword arguments (and any number of them).

key value pairs as arguments use '*' *to represent key value pair instead of* ''.

They are collected in a dictionary. Collection and unpacking work in the same way as the previous one.

In [21]:

```
def f3(a,b,*args,**kwarg):
    print("a and b values are",a,b)
    print("args=",args,type(args))
    print("kwarg=",kwarg,type(kwarg))

f3(2,3,4,5,"Hi",red='r',green='g',blue='b',x=2,y=4.4)
# f3(a=2,b=3,4,5,"Hi",red='r',green='g',blue='b',x=2,y=4.4)
# SyntaxError: positional argument follows keyword argument
```

```
a and b values are 2 3
args= (4, 5, 'Hi') <class 'tuple'>
kwarg= {'red': 'r', 'green': 'g', 'blue': 'b', 'x': 2, 'y': 4.4} <class 'dict'>
```

Nested functions (Inner functions)

Inner functions, also known as nested functions, are functions that you define inside other functions.

In Python, this kind of function has direct access to variables and names defined in the enclosing function.

Inner functions have many uses, most notably as closure factories and decorator functions.

Encapsulation: You use inner functions to protect them from everything happening outside of the function, meaning that they are hidden from the global scope. Let's look at the following example,

In [2]:
```
def outer(num1):
    def inner_inc(n):  # inner function hidden from outer code
        return n + 1

    num2 = inner_inc(num1) # call internally inner function
    print(num1, num2)

#inner_inc(10)   # Try calling inner function from here i.e., from outside
                 # NameError: name 'inner_inc' is not defined
outer(10)
```

```
10 11
```

In [27]:
```
def outer():
    print("this is an outer funtion")

    def inner():
        print("this is an inner function")

    inner()

outer()
#inner()   #NameError: name 'inner' is not defined
```

```
this is an outer funtion
this is an inner function
```

The function inner exists only when the function outer is called/invoked. Just like any variable that is used in within a function call, the function inner would only exist in the activation record of the outer function.

Here's an example of how to create and use a more elaborate inner function:

In [1]:
```
def factorial(number):
    # Validate input
    if not isinstance(number, int):
        raise TypeError("Sorry. 'number' must be an integer.")
    if number < 0:
        raise ValueError("Sorry. 'number' must be zero or positive.")

    def inner_factorial(number): # inner function
        if number <= 1:
            return 1
        return number*inner_factorial(number-1)

    return inner_factorial(number)  # call inner function and return its result

print(factorial(4)) # Call the outer function.
```

```
24
```

The main advantage of using this pattern is that, by performing all the argument checking in the outer function, you can safely skip error checking in the inner function and focus on the computation at hand.

Providing Encapsulation

A common use case of inner functions arises when you need to protect, or hide, a given function from everything happening outside of it so that the function is totally hidden from the global scope. This kind of behavior is commonly known as encapsulation.

In [3]:
```python
def increment(number):
    def inner_increment():
        return number + 1
    return inner_increment()

increment(10)
```

Out[3]:
```
11
```

Scope and Lifetime of variables:

Scope of a variable indicates the accessibility of the variable in the program.

Scope of a variable is confined to the level of indentation in which it was created and any level greater than itself. The variable is not accessible to codes that have lesser indentation.

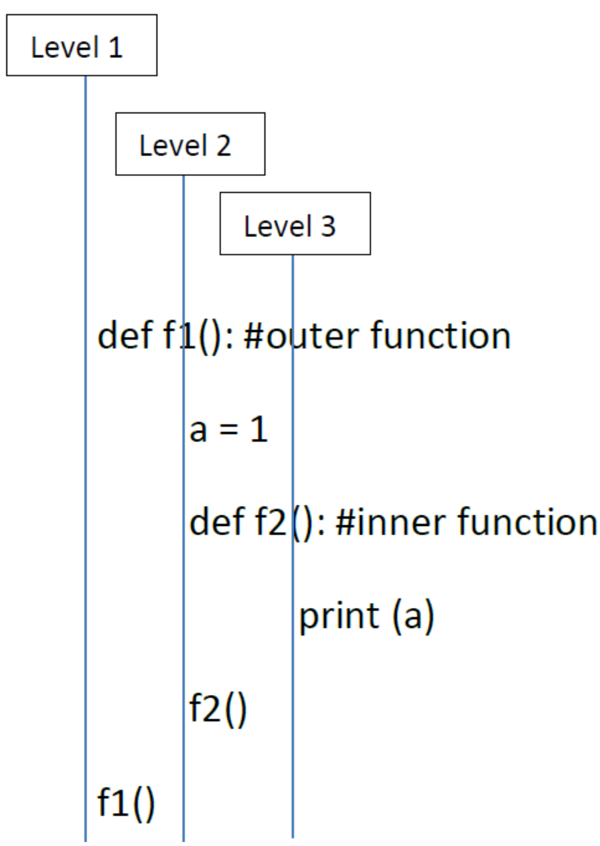
```
level-1
    level-2
        level-3
```

The variable has scope if it can be seen – is visible – in the current suite.

Lifetime or life of a variable indicates the time frame during which the variable and value is present in the memory.

Life of a variable is about existence of the variable – the variable has a location and therefore some value. The variable loses its life when the reference count becomes 0.

Let's explore the following example to understand these terms better.



In [12]:
```python
def f1(): #outer function
    a = 1
```

```
    def f2(): #inner function
        print(a)
    f2()
f1()
```

```
1
```

For the above program:

- Any variable created in level-1 of indentation is visible in itself (i.e., level-1) and all greater levels (2 and 3)
- Any variable created in level-2 of indentation is visible in itself (i.e., level-2) and all greater levels 3 and not level 1
- Any variable created in level-3 is only visible in level 3

In [13]:
```
def f1(): #outer function
    b = 2
    print(a) # a is defined in level-1
    def f2(): #inner function
        c=3
        print(a)   # a is defined in level-1
        print(b)   # b is defined in level-2
    f2()

a=1 #All names created outside of functions are global.
f1()
```

```
1
1
2
```

More Examples to illustrate the scope of variables:

In [14]:
```
def f1():   #outer function
    x = 1   # variable defined in the outer function
    def f2(a):   #inner function
        x = 4    #will create a new variable in the inner function
        print(a+x)
    print(x)    # prints the value of x of outer function
    f2(2)
    print(x)
f1()
```

```
1
6
1
```

Note: Whenever there is a local variable with the same name as that of a global/outer variable, the compiler/interpreter gives precedence to the local variable.

In [5]:
```
def f1():    #outer function
    a = [3,4]
    print(a)
    def f2():     #inner function
        a = [2,6]
        print(a)
    f2()
    print(a)
f1()
```

```
[3, 4]
[2, 6]
[3, 4]
```

In [6]:
```
def f1():    #outer function
    a = [3]  # single-element list
    print(a[0])
    def f2():     #inner function
        a[0] = 2
        print(a[0])
    f2()
    print(a[0])
f1()
```

```
3
2
2
```

In [7]:
```
# Nested functions can access the variables of the enclosing scope
def outer(a):
    def inner():
        print(a) #prints "hello"
    inner()
outer("hello")
```

```
hello
```

Global, Local and nonlocal Variables:

- All names created outside of functions are global.
- All names created within a function by default are local to those functions.
- Variables are local by default. So when variables are defined inside a function definition, they are local to the function by default. Thereby any changes to the local variables inside the function will not be reflected outside the function.
- All variables have the scope of the block, where they are declared and defined. They can only be used after the point of their declaration.
- Variables in Python are implicitly declared by defining them, i.e. the first time a value is assigned to a variable, that variable is declared and has automatically the data type of the object which has to be assigned to it.
- If we want to access variables outside the scope that it was defined in, we use the keyword global

Consider the following example :

In [12]:
```
x = 5
def f3():
    x = 10
    print("local x:", x)

f3()
print("global x:", x)
```

```
local x: 10
global x: 5
```

The interpreter always looks for the variable that's accessible easily. x in the function activation record can be accessed by the print function in f3 faster than x in the global frame

In [ ]:
```
x = 5
def f3():
    x = x + 10  #UnboundLocalError: local variable 'x' referenced before assignment
    print("local x:", x)

f3()
print("global x:", x)
```

If we want to access and modify the global variable within a function, all we have to do is use the keyword global before modifying it as shown in the code below

In [16]:
```
'''A function can use the value of a global variable without modifying it.
To change a global variable, the function should declare that it wants to play
with the global variable.
'''
a = 1
def f1():
    global a # causes the function to access the global variable and
             # does not create a new one
    a = 5 #accessing and modifying global variable
    print ('In function f1: a =',a)

print ('before function call: a =',a)
f1()
print ('after function call: a =',a)
```

```
before function call: a = 1
In function f1: a = 5
after function call: a = 5
```

In [18]:
```
a=1 #global variable

def f1():
    a=2 #local Variable
    print("a =",a)  #2

def f2():
    global a
    a=a+99 #accessing and modifying global variable
    print("a =",a)  #100

print("a =",a)  #1
f1()
f2()
print("a =",a)  #100
```

```
a = 1
a = 2
a = 100
a = 100
```

Nonlocal:

While global keyword always accesses the variables created in the global frame, while using nested functions, how can we access and modify the local variable of an outer fruntion?

If we want to access and modify a local variable created in an outer function by the inner function, we use the keyword nonlocal

In [18]:
```
def outer():
    x = 10 #local
    print('within outer x:',x)

    def inner():
        nonlocal x
        x = 20   # x from outer funtion
        print('within inner x:',x)

    inner()
    print('within outer x:',x)

x = 5 #global
print('Before outer x:',x)
```

```
outer()
print('After outer x:',x)
```

```
Before outer x: 5
within outer x: 10
within inner x: 20
within outer x: 20
After outer x: 5
```

Exercise Problems

In [1]:

```
def f1():
    print("this is function")
print(f1)

del f1
#f1() #NameError: name 'f1' is not defined
```

```
<function f1 at 0x000002F6BB45D550>
```

In [2]:

```
def foo():
    print("Inside function definition")

bar=foo
del foo
bar()
```

```
Inside function definition
```

References:

1. function_parameters_3.pdf – Prof. N S Kumar, Dept. of CSE, PES University.
2. https://www.w3schools.com/python
3. https://docs.python.org/
4. https://realpython.com/defining-your-own-python-function/

In [ ]:

```

```