Capítulo 11

Funciones

Function Basics

- A function is a “wrapper” of statements performing some actions
- Every function has a name, receive some arguments used to make some transformations and return some values

```
def function_name (arg1, arg2, arg3) :
    …
    …
    …
return value
```

Functions

- Python provide us with many functions to use directly. We have used some of these functions such as ***print()***, ***input()***, ***len()***, ***pow()***, etc.

- Additionally, the users can create their own functions.

- Python also permit us to collect a group of functions as a library. Later, we can use this library in our programs (importing these functions to our programs).

- The idea of using functions enable us to use the method of modular programing, where every module is responsible for a certain task.

- In modular programing every different task of a program is assigned to a function. In order to execute the function the program has to call the function.

Functions

- In order to follow modular programing we will divide a complex project into simpler tasks, every simple task can be codified as an independent block (function).

- So generally, in modular programing, the program is made of blocks of code called functions. Every block or function is responsible for a specific task.

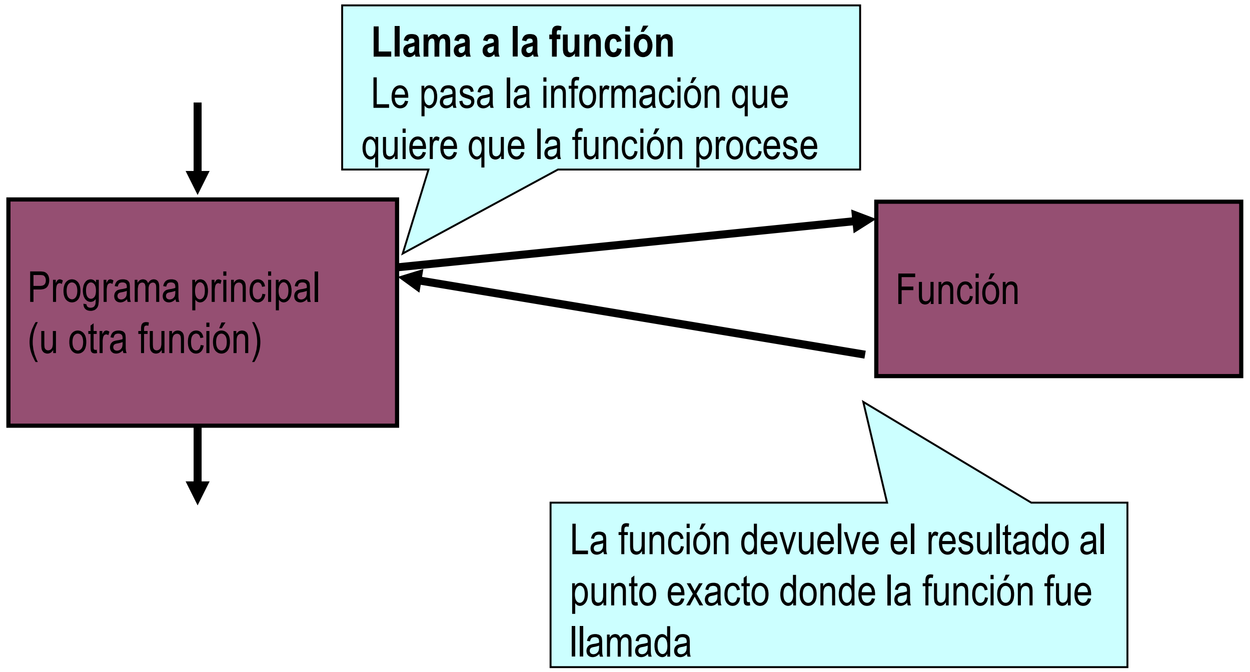
- Any name but Python keywords

- Preserve indentation inside the function definition

- **Advantages of using functions**:
  - ➢To implement new functionalities
  - ➢To avoid repeating code
  - ➢To have a better structure
  - ➢To have a more readable piece of code
  - ➢Creates more clear programs.
  - ➢The functions written in one program can be used later in other programs.

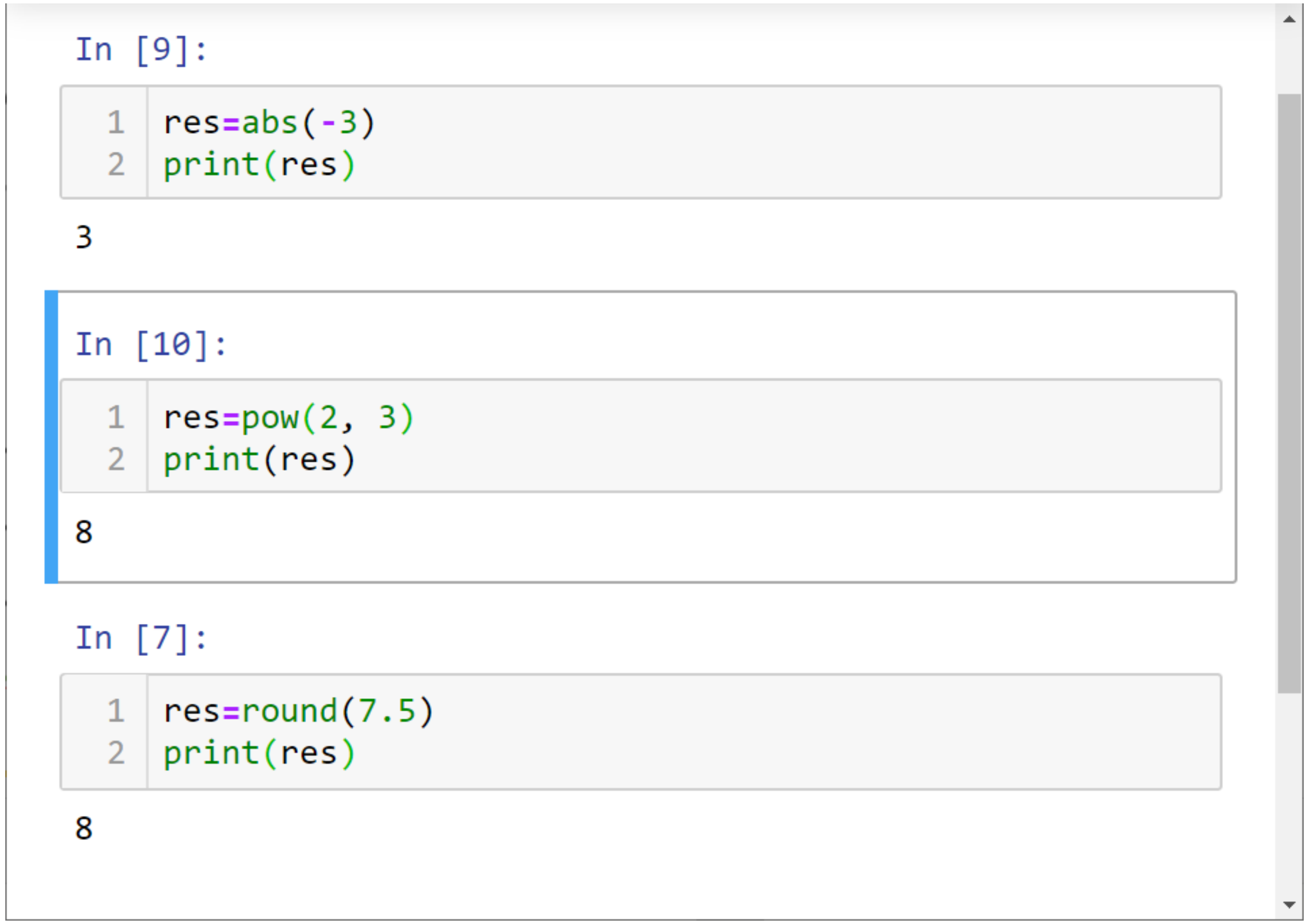
Functions

- **What is a function**: A function can be defined as a group of instructions (codes) that can do a specific task.
- Once the functions are written we can use them when necessary by invoking them. To activate the function we call the function.
- Every time a function is called the control of execution of the program will be transferred to that function. When the function is finished, the control of the execution goes back to the point where we called.
- We can call a function as many times as we want without limits. Even a function can call another function. By doing so, we can create very complex programs.


Llama a la función
Le pasa la información que quiere que la función procese
Programa principal (u otra función)
Función
La función devuelve el resultado al punto exacto donde la función fue llamada

Funciones

- Tipos
  - Predefinidas (built-in-functions.): abs, pow, round, etc.



```
In [9]:
res=abs(-3)
print(res)

3

In [10]:
res=pow(2, 3)
print(res)

8

In [7]:
res=round(7.5)
print(res)

8
```

Funciones

- Tipos funciones
  - Incorporadas en módulos. Deben importarse antes de usarse. Ejemplo: sin, cos

```python
import math
seno_pi=math.sin(90*2*math.pi/360)
print(seno_pi)
```

```
1.0
```

```python
import numpy as np
notas=[4,5,6]
media=np.mean(notas)
print(media)
```

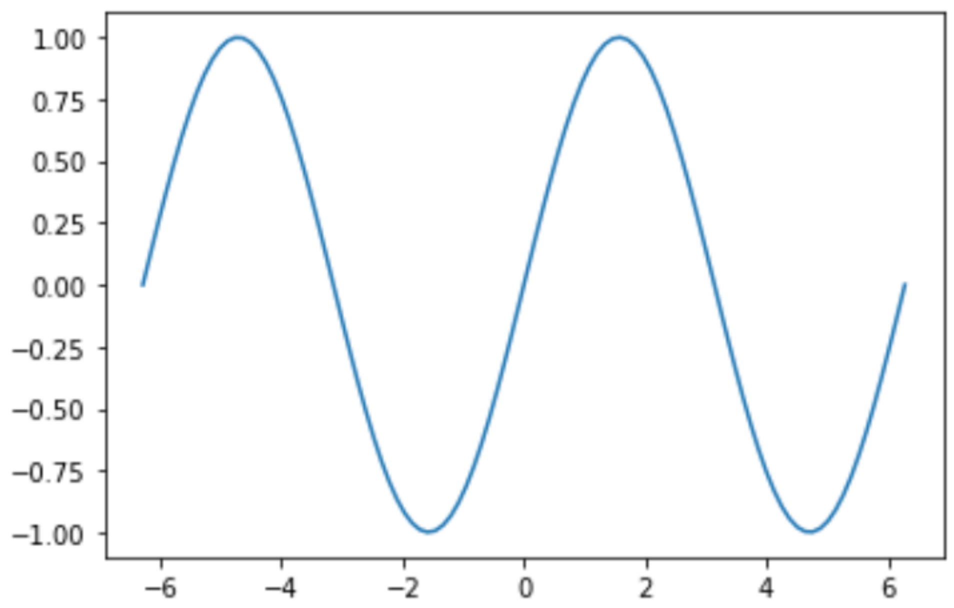
```
5.0
```

```python
from math import sin, pi
res=sin(90*2*pi/360)
print(res)
```

```
1.0
```

```python
import numpy as np
import matplotlib.pyplot as plt
x=np.linspace(-2*np.pi,2*np.pi,100)
y=np.sin(x)
plt.plot(x, y)
```

```
[<matplotlib.lines.Line2D at 0x209f4b9dcf8>]
```



Programmer-defined functions

- Tipos
  - Creadas por el programador. Permite dividir los programas en un conjunto de pequeños componentes (autocontenidos), cada uno de los cuales con un propósito

Head

Body

```
def nombre_funcion(param1, param2, ...,param_n):
    instruction_1
    instructión_2
    ...
    instruction_n
    return val_1, val_2, ...val_n
```

```
var1, var2, … = nombre_funcion(param1, param2, ...,param_n)
```

Para llamar a una función se especifica su nombre seguida por una lista de argumentos encerrados entre paréntesis, separados por comas. Si la función devuelve uno o más valores, la llamada a la función se asigna a una o más variables. Si la función no devuelve nada la llamada aparece sola.

Programmer-defined functions

```
def function_name(param1, param2, ...,param_n):
    instruction_1
    instructión_2
    ...
    instruction_n
    return val1, val2, ...valn
```

- function_name
  - Name of the function that is used to call the function anywhere in the program
  - Same limitations as any identifier name
- parameters (parameter_1, parameter_2, …parameter_n)
  - They represent the names of data items that are transferred into the function from the calling portion of the program
  - They are also known as ***formal parameters***
- An empty pair of parentheses MUST follow the function name if the function definition does not include any arguments
- : (Colon)
  - It marks the beginning of the body of the function (compound statement that defines the action to be taken by the function)
- instruction_ 1;… instruction_n
  - Instructions that make up the body of the function
  - They must be indented by some blank spaces to clearly delimit the beginning and end of the function

Functions

- **Function calls**:
  - To call a function write the name of the function and a pair of parenthesis, inside the parenthesis you must indicate the parameters (variables) that the function needs separated by commas .
  - If the function call does not require any arguments, an empty pair of parentheses must follow the name of the function
  - The arguments appearing in the function call are referred to as ***actual parameters*** or arguments, in contrast to the ***formal parameters*** that appear in the first line of the function definition. The number of actual arguments must be the same as the number of formal arguments
  - If the function returns one o more values, the function access is often written as an assignment statement; e.g.,

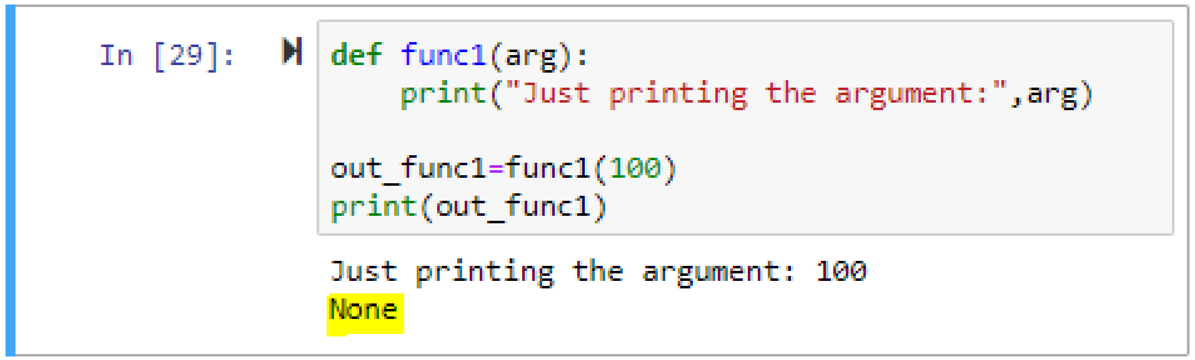
    y = polynomial(x)
  - If the function does not return anything, the function access appears by itself; e.g., display (a, b, c);

Programmer-defined functions

```
def function_name(param1, param2, ...,param_n):
    instruction_1
    instructión_2
    ...
    instruction_n
    return val1, val2, ...valn
```

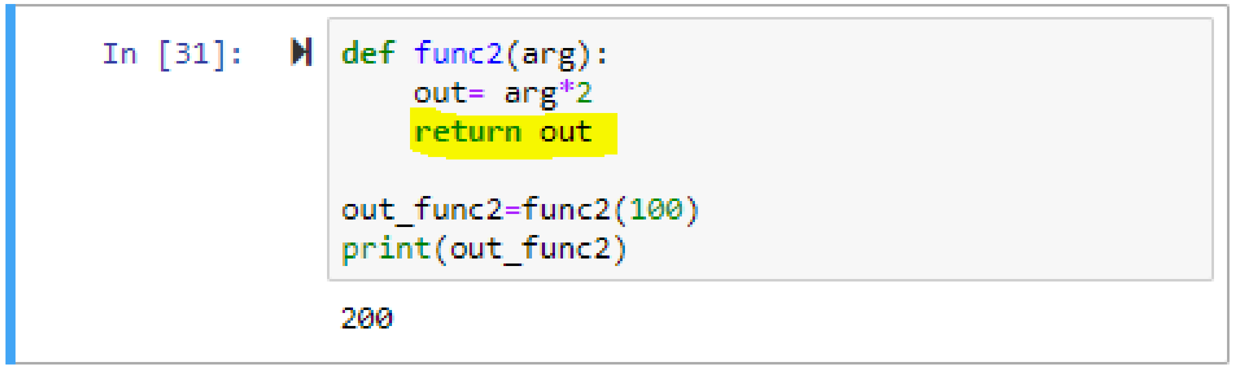
- ***return*** var_1, var_2, ..., var_n
  - Last instruction in the body of the function
  - Causes an immediate exit from the function and returns the value of variables or expressions to the calling portion of the program
  - If the don´t return any value, the **return** statement simply causes control to revert back to the calling portion of the program. Only in this case the **return** statement can be omitted, and the function will terminate on reaching the last sentence

Function returning no values



```
In [29]:  def func1(arg):
              print("Just printing the argument:",arg)

          out_func1=func1(100)
          print(out_func1)

          Just printing the argument: 100
          None
```

Function returning a value

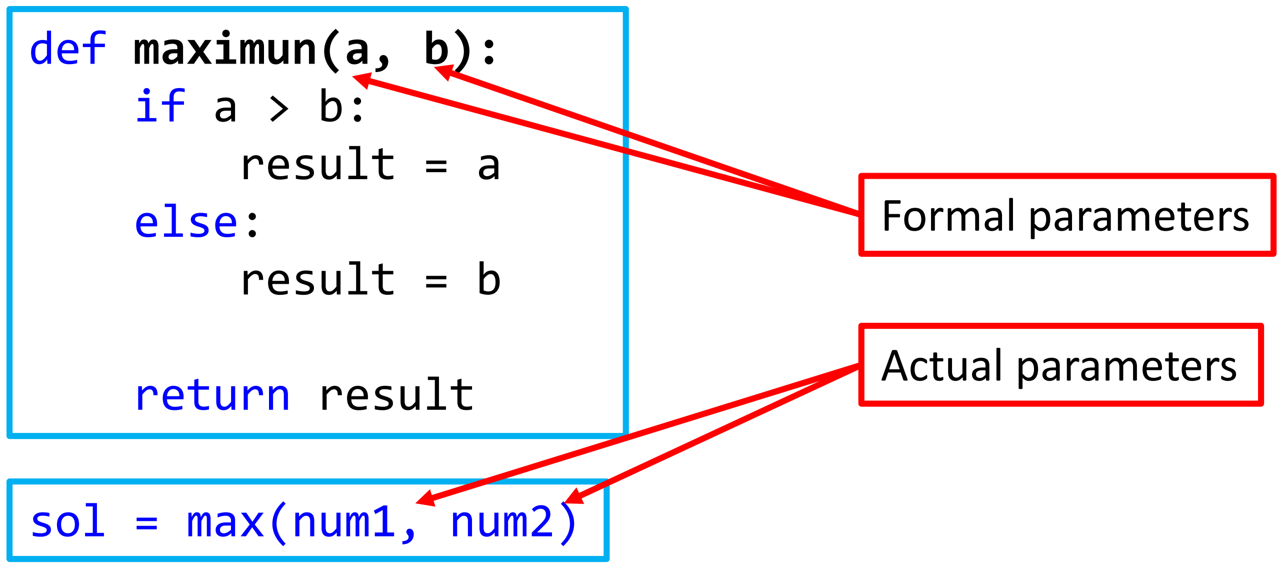


```
In [31]:  def func2(arg):
              out= arg*2
              return out

          out_func2=func2(100)
          print(out_func2)

          200
```

Luis F. Sánchez Merchante

Formal and Actual Parameters

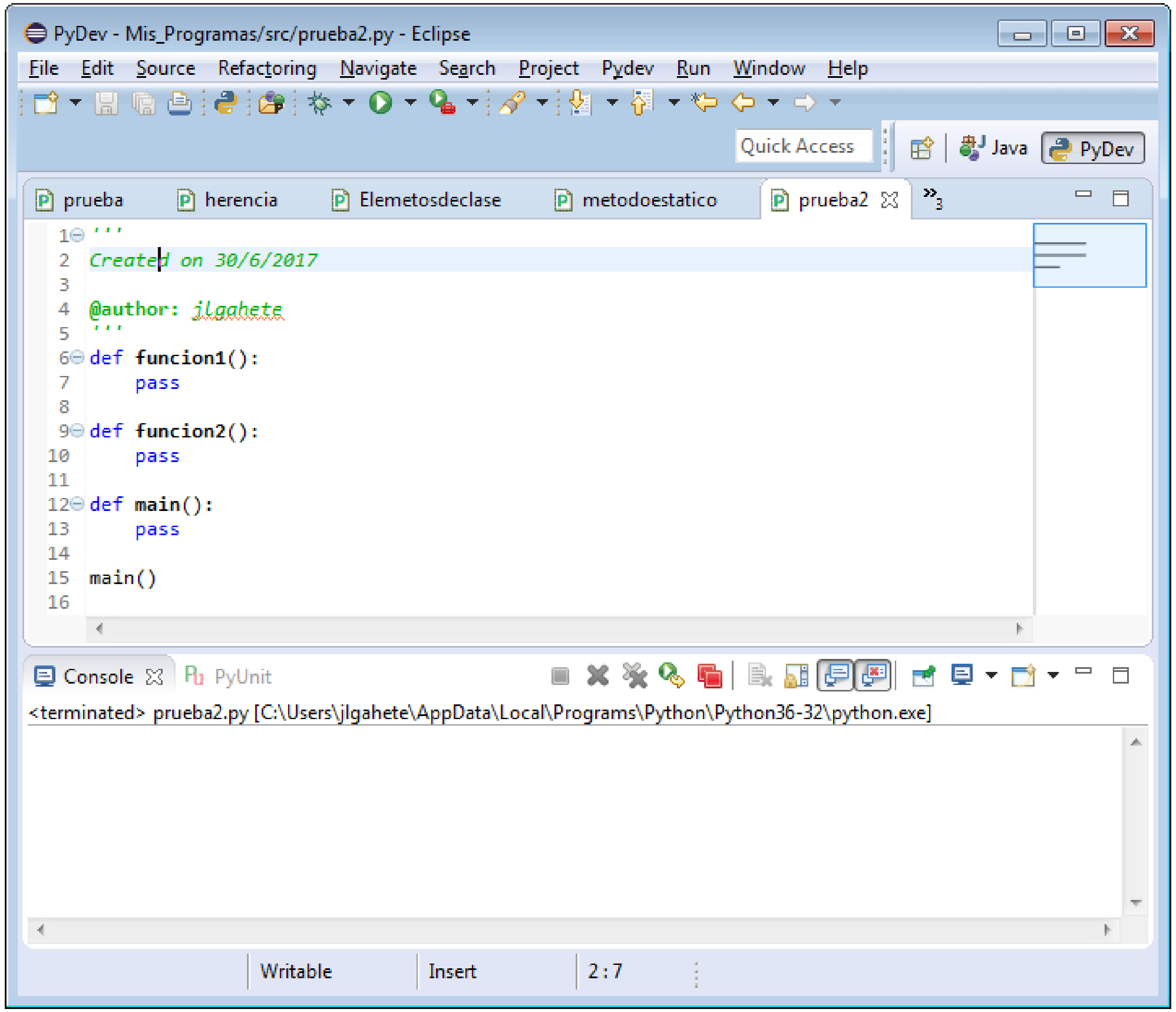
- Formal parameters:
  - Variables that receive the adress of the arguments used in the function call
  - Variables that appear in the first line of the function definition
  - They are local variables:
    - Recognized only within the function
- Actual parameters:
  - Those variables used to refer to the function
  - Variables that appear in the function call



```
def maximun(a, b):
    if a > b:
        result = a
    else:
        result = b

    return result
```

```
sol = max(num1, num2)
```

Organización de las funciones en el programa

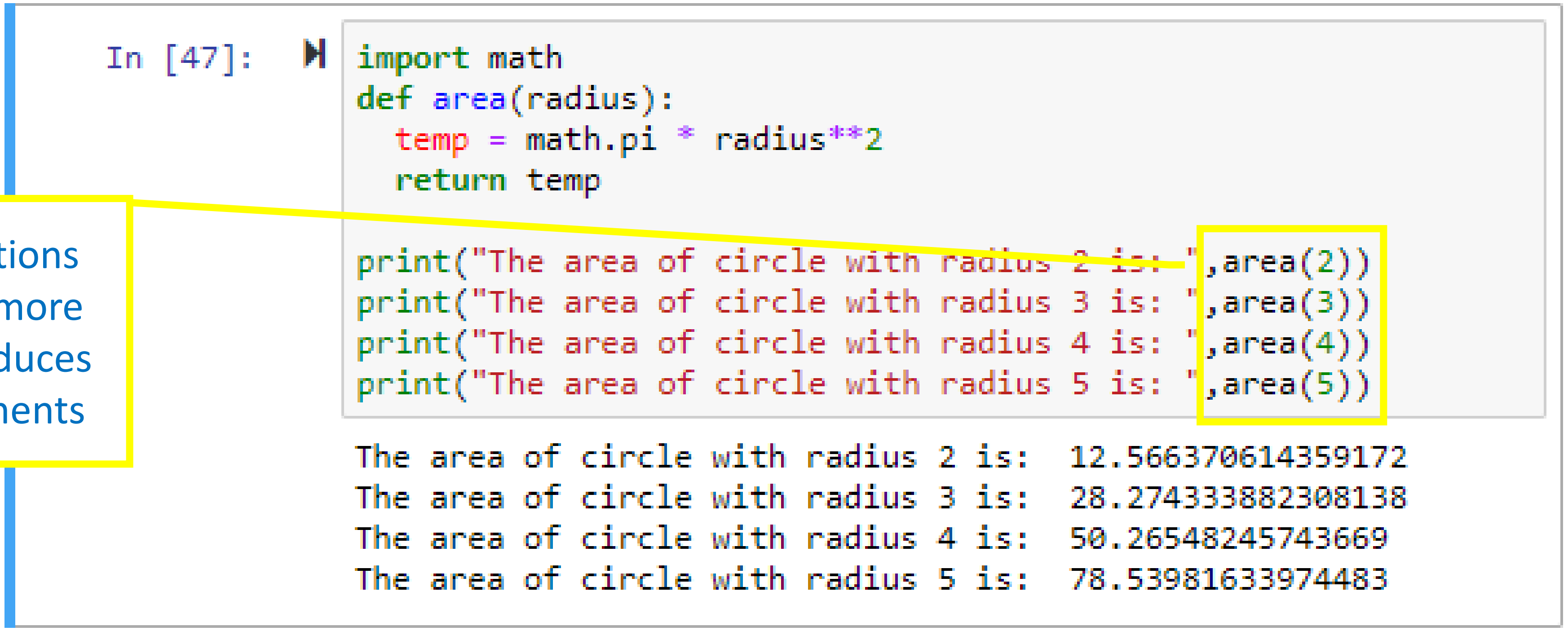

PyDev - Mis_Programas/src/prueba2.py - Eclipse
File Edit Source Refactoring Navigate Search Project Pydev Run Window Help
Quick Access
Java
PyDev
prueba
herencia
Elemetosdeclase
metodoestatico
prueba2
Console
PyUnit
Writable
Insert
2 : 7

```
'''
Created on 30/6/2017

@author: jlgahete
'''
def funcion1():
    pass

def funcion2():
    pass

def main():
    pass

main()

```

```
<terminated> prueba2.py [C:\Users\jlgahete\AppData\Local\Programs\Python\Python36-32\python.exe]
```

Returning values

- The most common structure is returning some variable created inside



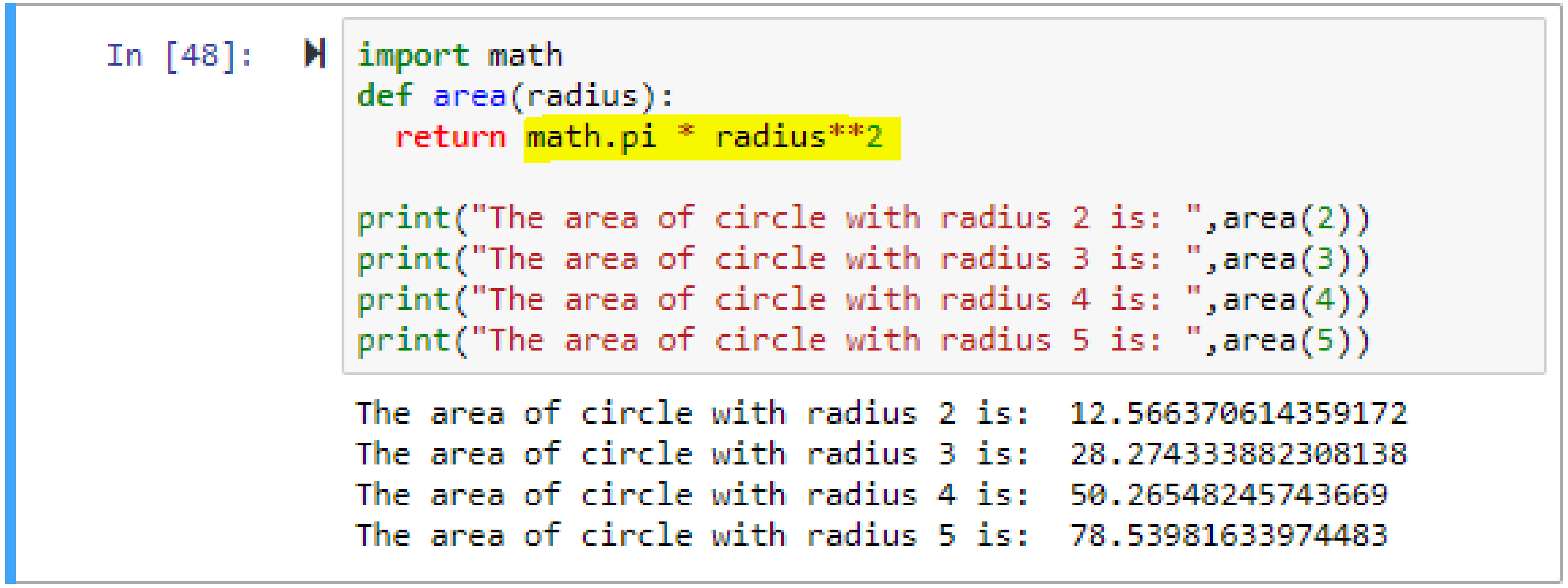
```
In [47]:  import math
          def area(radius):
            temp = math.pi * radius**2
            return temp

          print("The area of circle with radius 2 is: ",area(2))
          print("The area of circle with radius 3 is: ",area(3))
          print("The area of circle with radius 4 is: ",area(4))
          print("The area of circle with radius 5 is: ",area(5))

          The area of circle with radius 2 is:  12.566370614359172
          The area of circle with radius 3 is:  28.274333882308138
          The area of circle with radius 4 is:  50.26548245743669
          The area of circle with radius 5 is:  78.53981633974483
```

Using that functions make the code more readable and reduces repeated statements

Luis F. Sánchez Merchante

Returning values

- Temporary variables sometimes can be skipped
- But using variables makes debugging easier

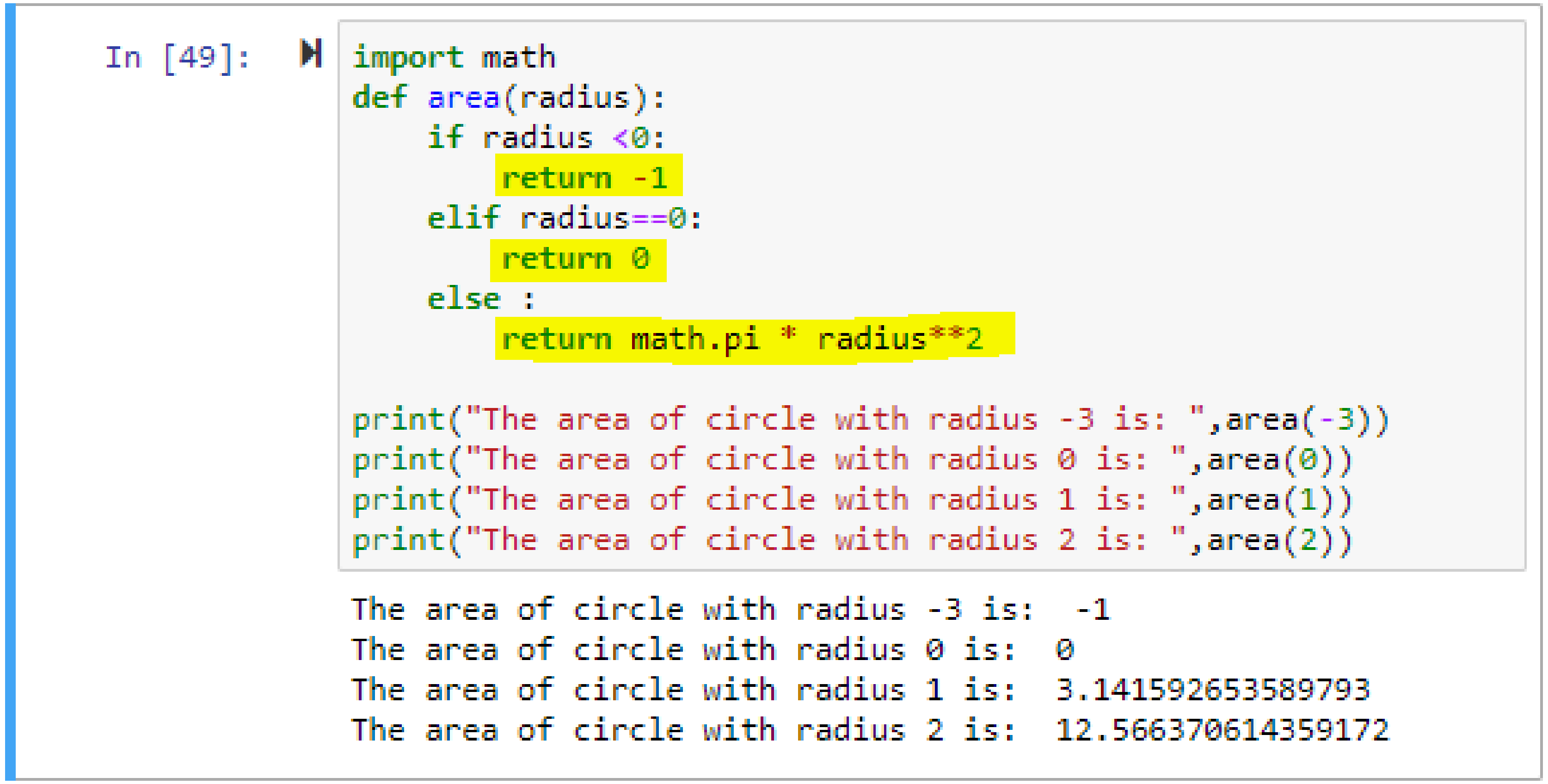


```
In [48]:
import math
def area(radius):
  return math.pi * radius**2

print("The area of circle with radius 2 is: ",area(2))
print("The area of circle with radius 3 is: ",area(3))
print("The area of circle with radius 4 is: ",area(4))
print("The area of circle with radius 5 is: ",area(5))
```

```
The area of circle with radius 2 is:  12.566370614359172
The area of circle with radius 3 is:  28.274333882308138
The area of circle with radius 4 is:  50.26548245743669
The area of circle with radius 5 is:  78.53981633974483
```

Returning values

- More than one return statement is allowed



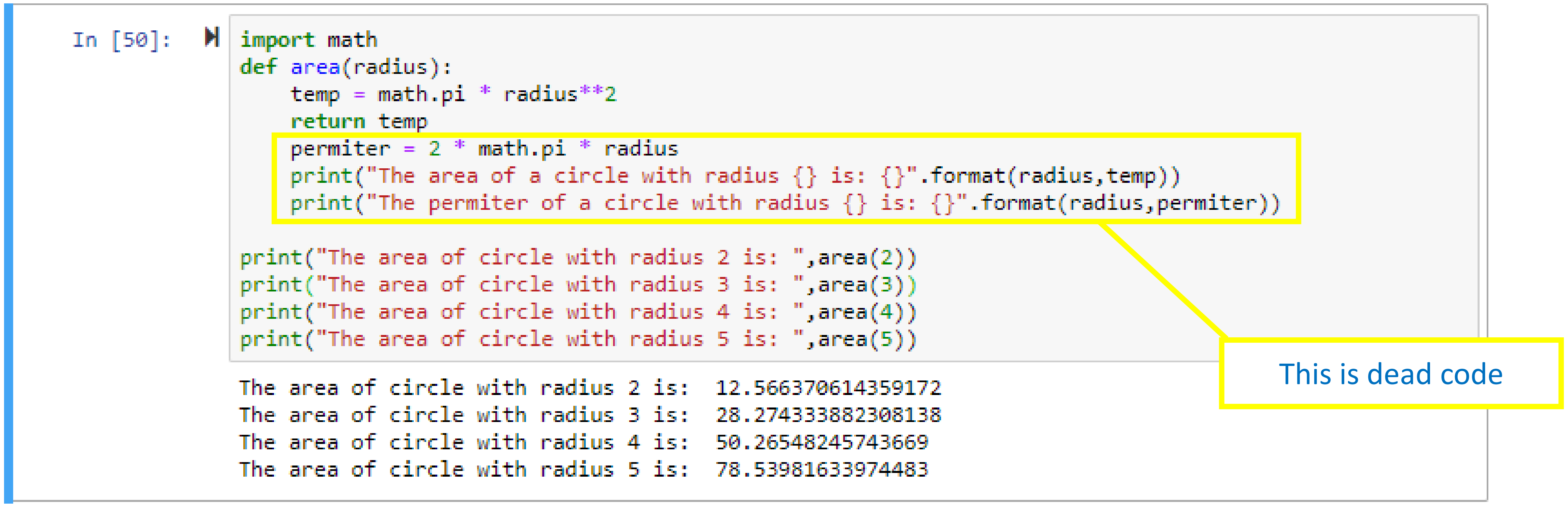
In [49]:

```
import math
def area(radius):
    if radius <0:
        return -1
    elif radius==0:
        return 0
    else :
        return math.pi * radius**2

print("The area of circle with radius -3 is: ",area(-3))
print("The area of circle with radius 0 is: ",area(0))
print("The area of circle with radius 1 is: ",area(1))
print("The area of circle with radius 2 is: ",area(2))
```

```
The area of circle with radius -3 is:  -1
The area of circle with radius 0 is:  0
The area of circle with radius 1 is:  3.141592653589793
The area of circle with radius 2 is:  12.566370614359172
```

Dead code

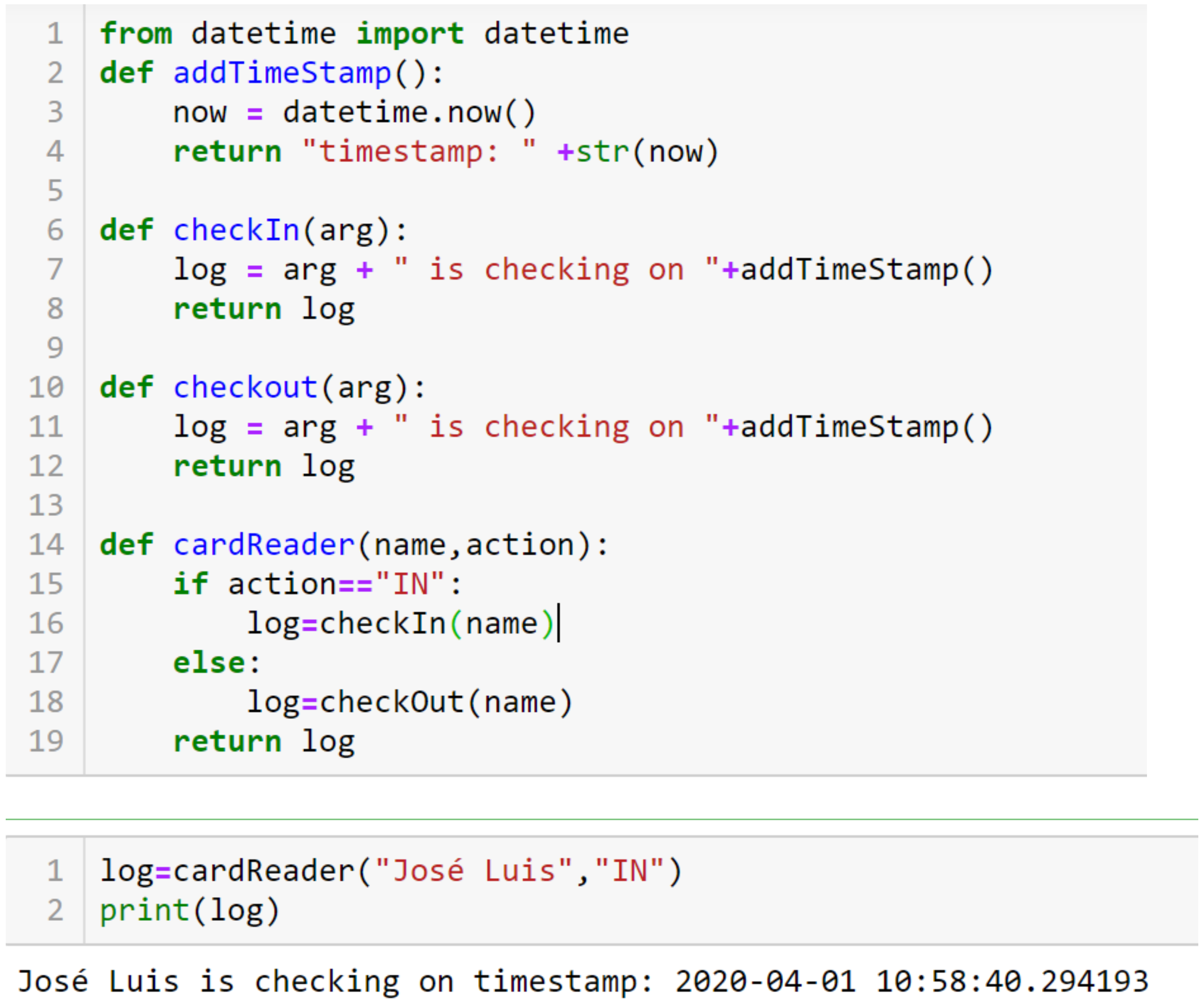
- Note that all the code after a return statements will never be executed



```
In [50]:  import math
          def area(radius):
              temp = math.pi * radius**2
              return temp
              permiter = 2 * math.pi * radius
              print("The area of a circle with radius {} is: {}".format(radius,temp))
              print("The permiter of a circle with radius {} is: {}".format(radius,permiter))

          print("The area of circle with radius 2 is: ",area(2))
          print("The area of circle with radius 3 is: ",area(3))
          print("The area of circle with radius 4 is: ",area(4))
          print("The area of circle with radius 5 is: ",area(5))

          The area of circle with radius 2 is:  12.566370614359172
          The area of circle with radius 3 is:  28.274333882308138
          The area of circle with radius 4 is:  50.26548245743669
          The area of circle with radius 5 is:  78.53981633974483
```

Composition

- Functions can be called from within another
- A function can call itself



```python
from datetime import datetime
def addTimeStamp():
    now = datetime.now()
    return "timestamp: " +str(now)

def checkIn(arg):
    log = arg + " is checking on "+addTimeStamp()
    return log

def checkout(arg):
    log = arg + " is checking on "+addTimeStamp()
    return log

def cardReader(name,action):
    if action=="IN":
        log=checkIn(name)
    else:
        log=checkOut(name)
    return log
```

```python
log=cardReader("José Luis","IN")
print(log)
```

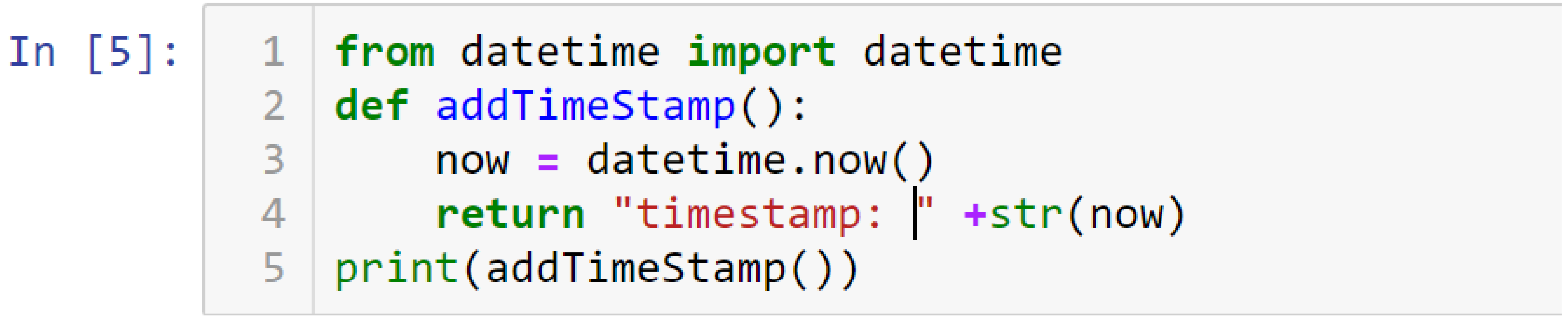
```
José Luis is checking on timestamp: 2020-04-01 10:58:40.294193
```

TIPOS DE ARGUMENTOS EN LLAMADAS A FUNCIONES: POSICIONALES Y NOMBRADOS

- Hasta el momento, deben coincidir en número los parámetros actuales (reales o ficticios) con el número de parámetros formales
- Orden:
  1. Posicional: Se respeta el orden de los parámetros formales y se asignan los valores de los parámetros actuales en su correspondiente formal
  2. Nombrados: No se respeta el orden de los parámetros formales. Se debe usar en los argumentos el formato nombre_param_formal = valor
- Se pueden mezclar, pero si se utiliza un argumento nombrado ya no puede aparecer después uno posicional

Passing arguments

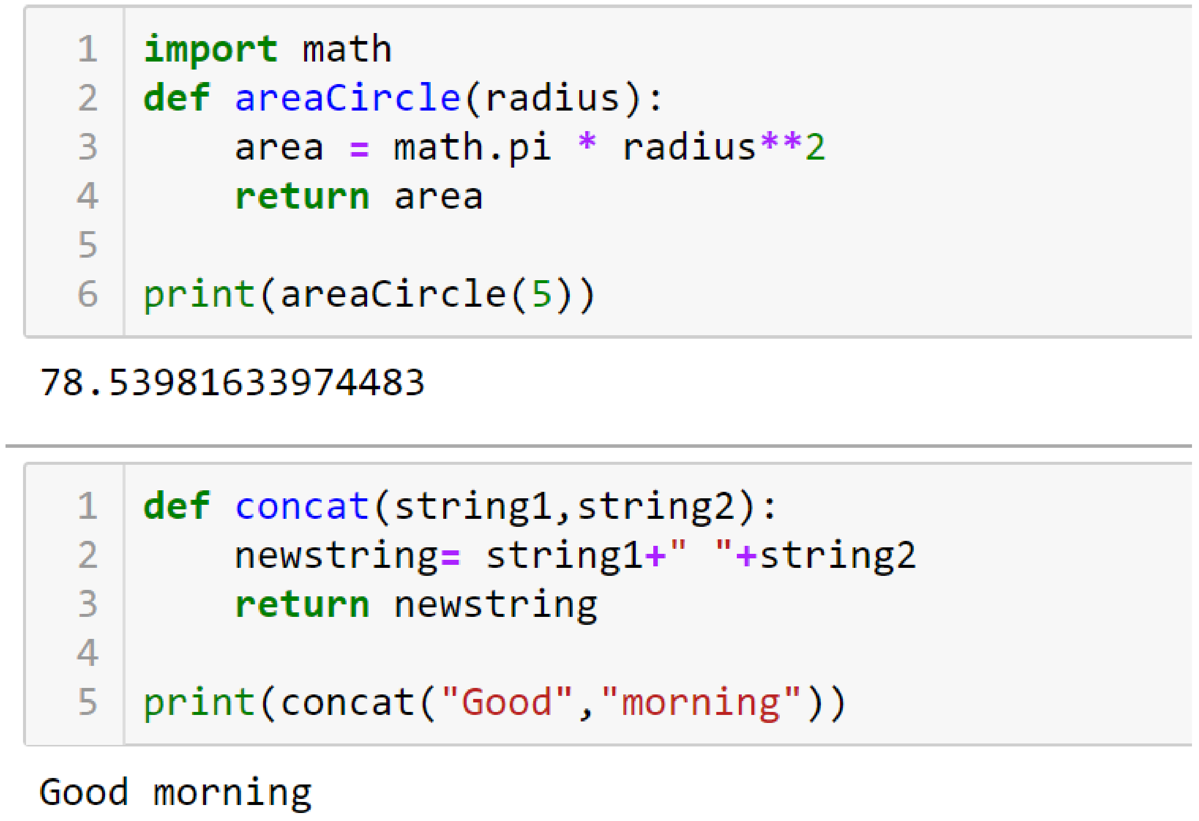
- Arguments are not mandatory



In [5]:
```
from datetime import datetime
def addTimeStamp():
    now = datetime.now()
    return "timestamp: " +str(now)
print(addTimeStamp())
```

Passing arguments

- Normally they have one or several



```
import math
def areaCircle(radius):
    area = math.pi * radius**2
    return area

print(areaCircle(5))
```

```
78.53981633974483
```

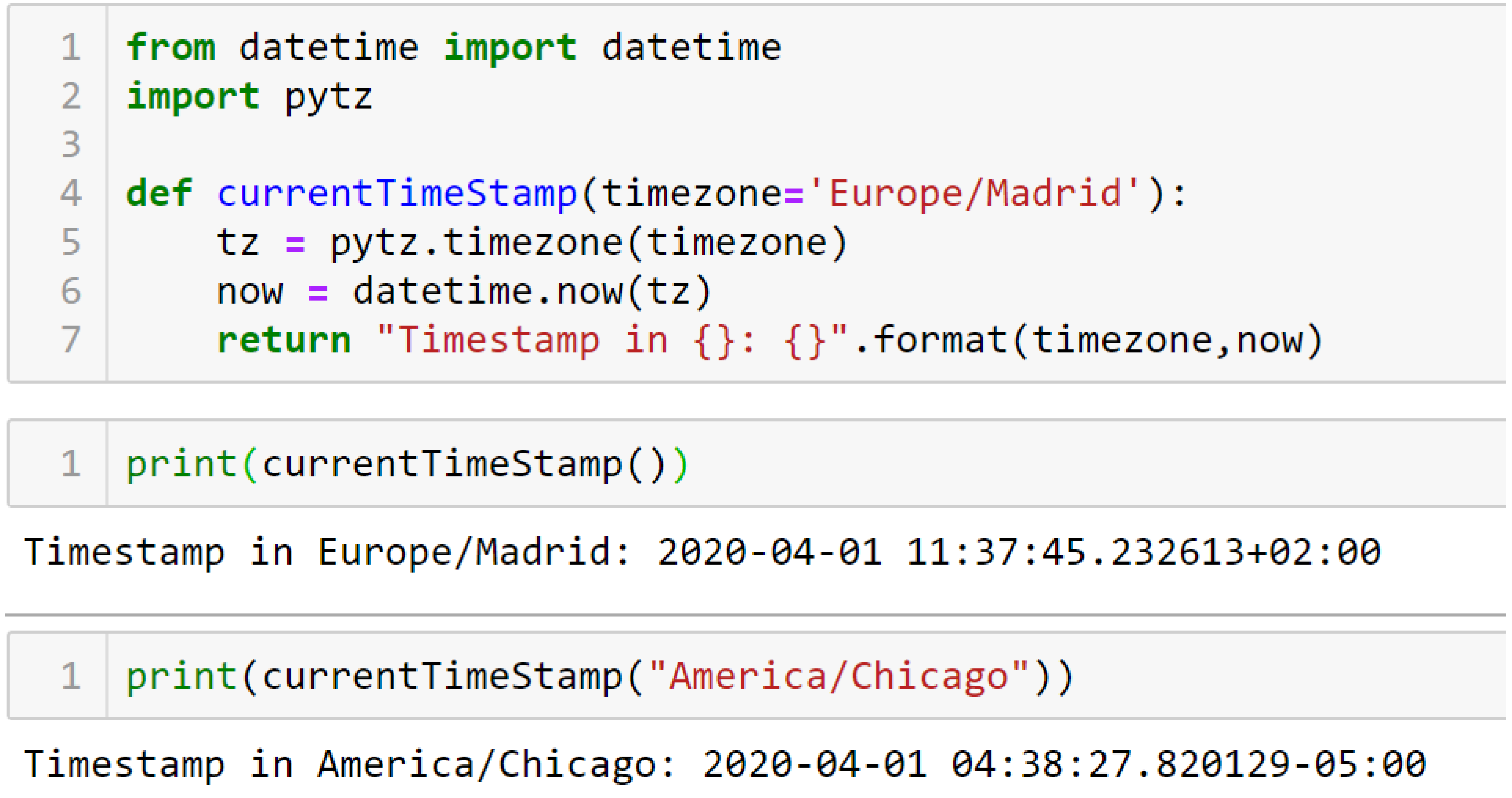
```
def concat(string1,string2):
    newstring= string1+" "+string2
    return newstring

print(concat("Good","morning"))
```

```
Good morning
```

Luis F. Sánchez Merchante

Passing arguments

- We can assign default values



```python
from datetime import datetime
import pytz

def currentTimeStamp(timezone='Europe/Madrid'):
    tz = pytz.timezone(timezone)
    now = datetime.now(tz)
    return "Timestamp in {}: {}".format(timezone,now)
```

```python
print(currentTimeStamp())
```

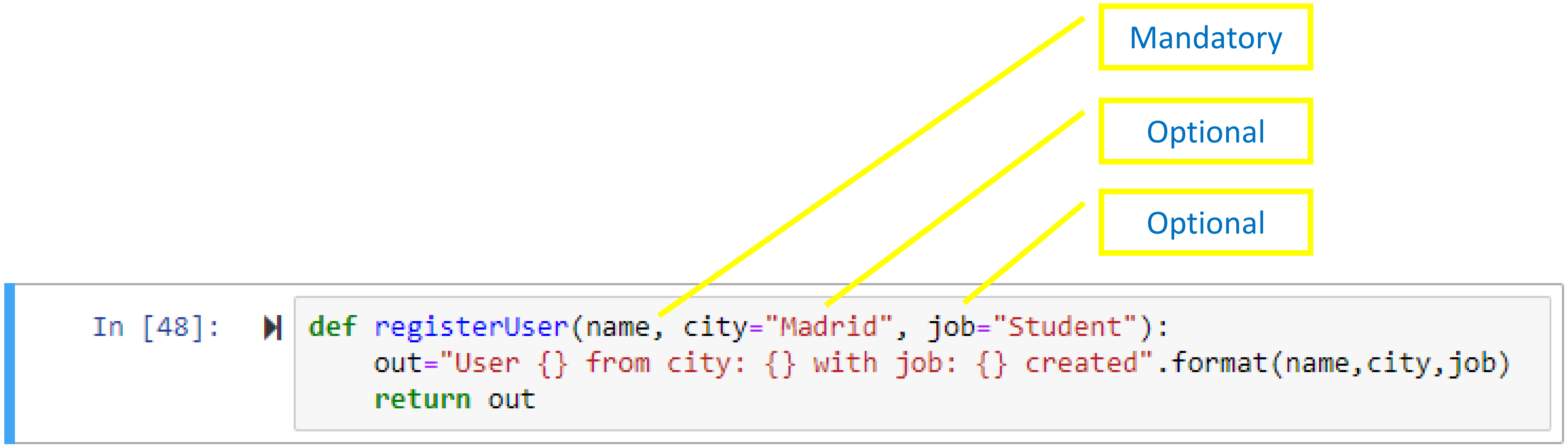
```
Timestamp in Europe/Madrid: 2020-04-01 11:37:45.232613+02:00
```

```python
print(currentTimeStamp("America/Chicago"))
```

```
Timestamp in America/Chicago: 2020-04-01 04:38:27.820129-05:00
```

Passing arguments

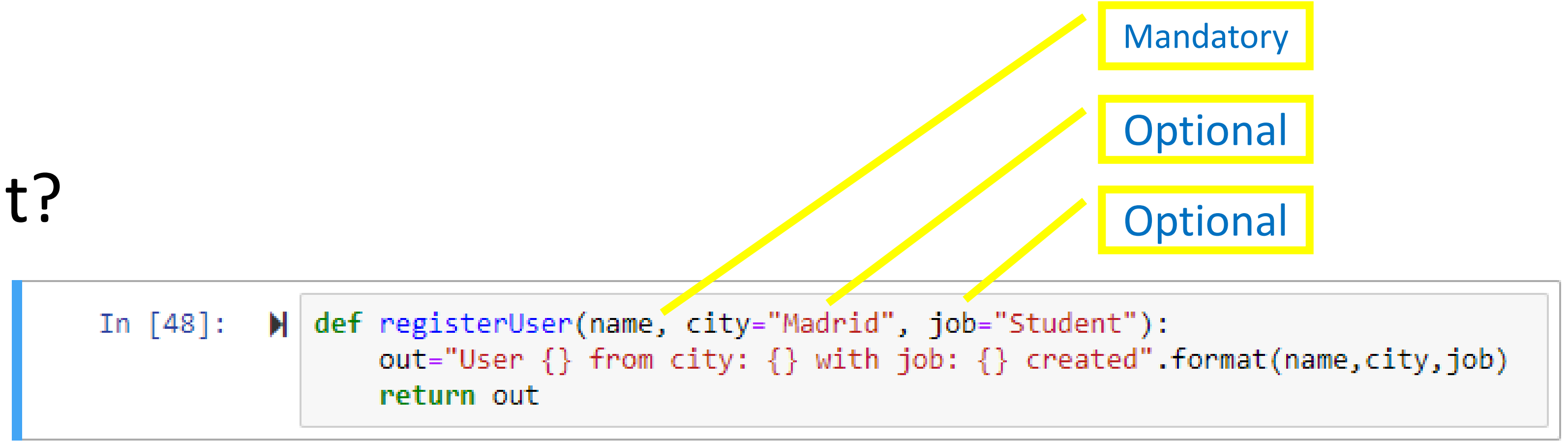
- The arguments order is relevant



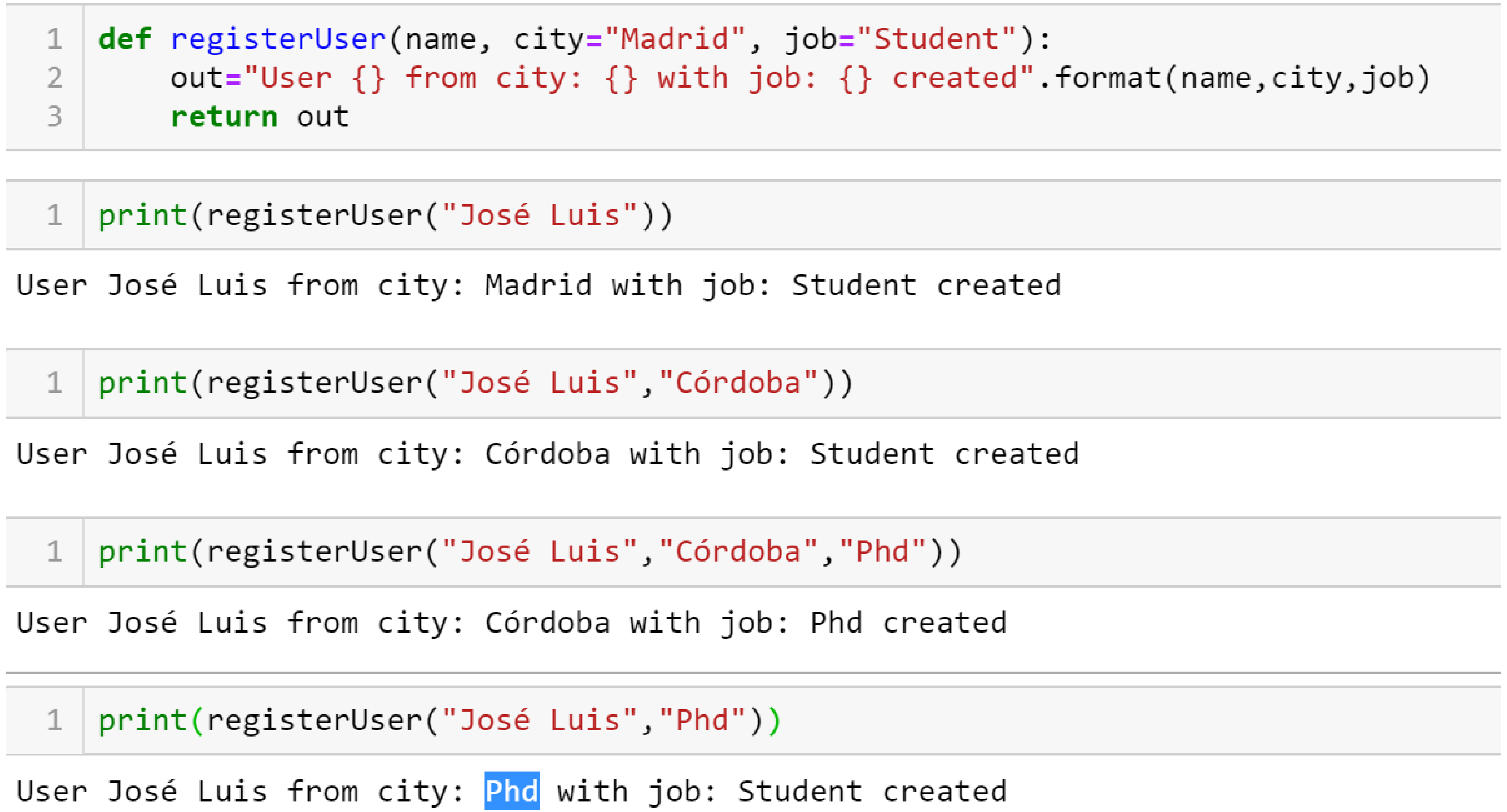
```
def registerUser(name, city="Madrid", job="Student"):
    out="User {} from city: {} with job: {} created".format(name,city,job)
    return out
```

Passing arguments

- How can we sort this issue out?



```
In [48]:  def registerUser(name, city="Madrid", job="Student"):
               out="User {} from city: {} with job: {} created".format(name,city,job)
               return out
```



```
def registerUser(name, city="Madrid", job="Student"):
    out="User {} from city: {} with job: {} created".format(name,city,job)
    return out
```

```
print(registerUser("José Luis"))
```

```
User José Luis from city: Madrid with job: Student created
```

```
print(registerUser("José Luis","Córdoba"))
```

```
User José Luis from city: Córdoba with job: Student created
```

```
print(registerUser("José Luis","Córdoba","Phd"))
```

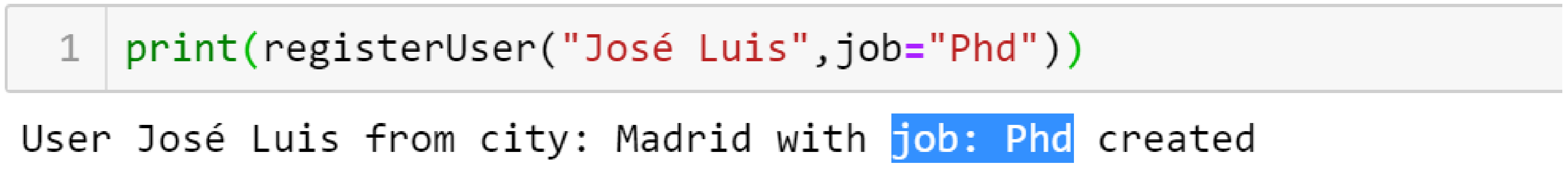
```
User José Luis from city: Córdoba with job: Phd created
```

```
print(registerUser("José Luis","Phd"))
```

```
User José Luis from city: Phd with job: Student created
```

Passing arguments

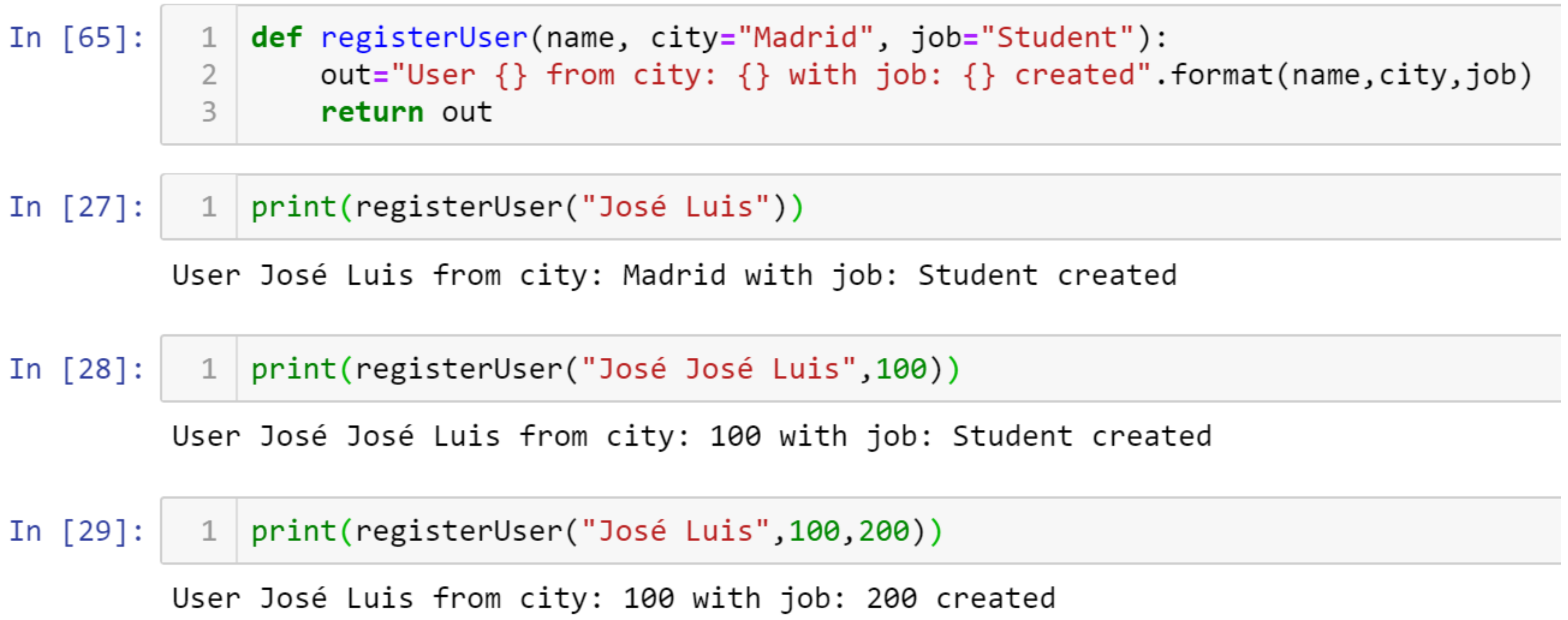
- Where there exists ambiguation, use explicit naming for the arguments



```
print(registerUser("José Luis",job="Phd"))
```

```
User José Luis from city: Madrid with job: Phd created
```

- Note that Python is not TYPESAFE, so the type does not help with disambiguation



```
In [65]:  def registerUser(name, city="Madrid", job="Student"):
              out="User {} from city: {} with job: {} created".format(name,city,job)
              return out
```

```
In [27]:  print(registerUser("José Luis"))
```

```
User José Luis from city: Madrid with job: Student created
```

```
In [28]:  print(registerUser("José José Luis",100))
```

```
User José José Luis from city: 100 with job: Student created
```

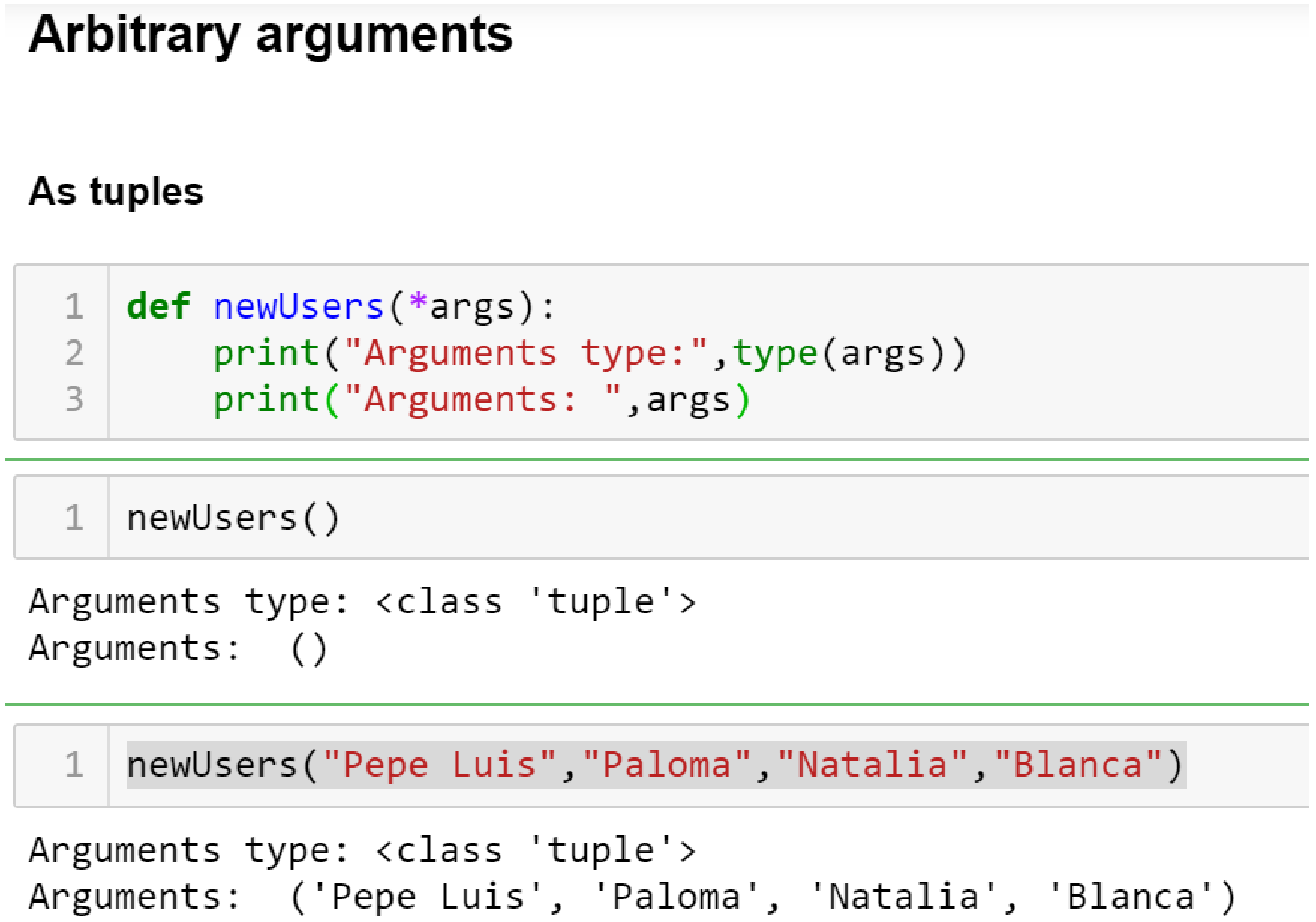
```
In [29]:  print(registerUser("José Luis",100,200))
```

```
User José Luis from city: 100 with job: 200 created
```

Luis F. Sánchez Merchante

Passing arbitrary arguments

- Sometimes the number of arguments is variable



Arbitrary arguments

As tuples

```
def newUsers(*args):
    print("Arguments type:",type(args))
    print("Arguments: ",args)
```

```
newUsers()
```

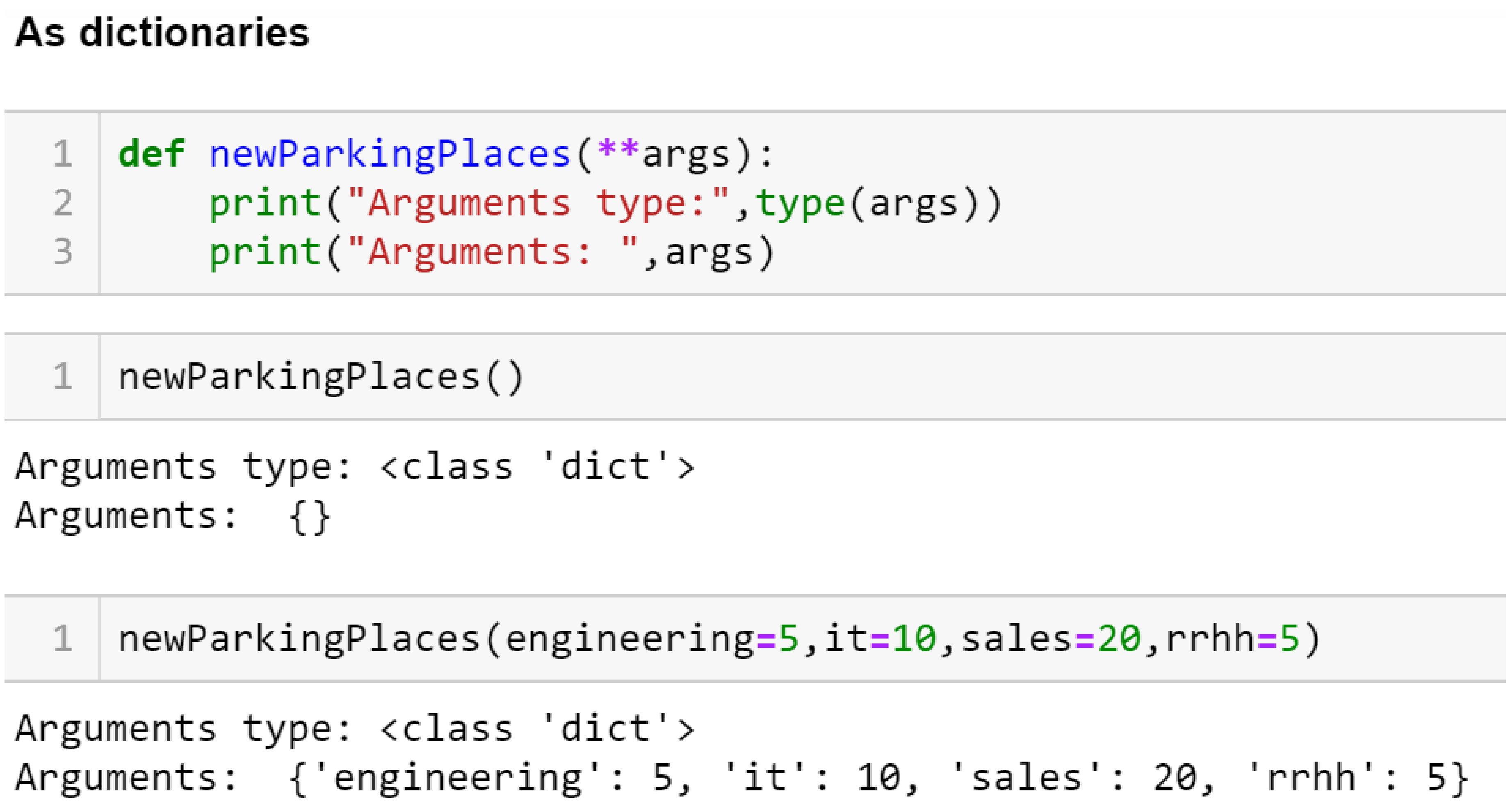
```
Arguments type: <class 'tuple'>
Arguments:  ()
```

```
newUsers("Pepe Luis","Paloma","Natalia","Blanca")
```

```
Arguments type: <class 'tuple'>
Arguments:  ('Pepe Luis', 'Paloma', 'Natalia', 'Blanca')
```

Passing arbitrary arguments

- More flexibility can be achieved using dictionaries



As dictionaries

```python
def newParkingPlaces(**args):
    print("Arguments type:",type(args))
    print("Arguments: ",args)
```

```python
newParkingPlaces()
```

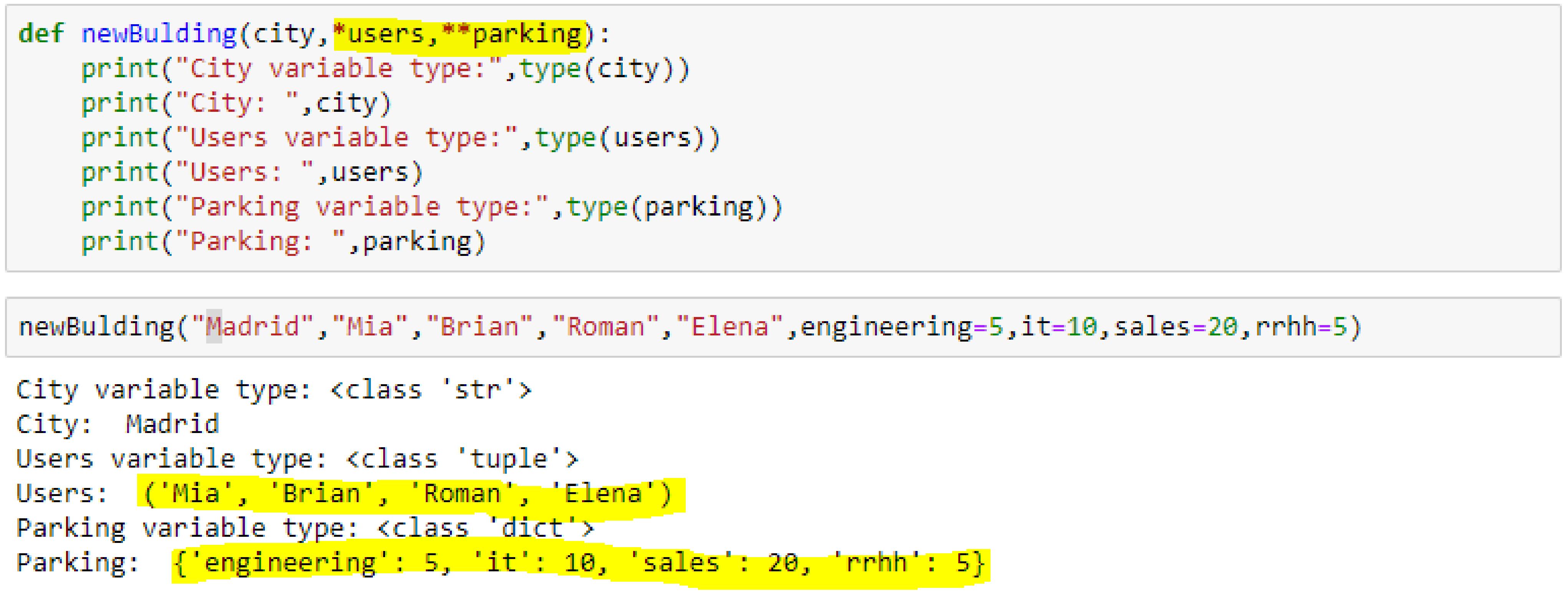
```
Arguments type: <class 'dict'>
Arguments:  {}
```

```python
newParkingPlaces(engineering=5,it=10,sales=20,rrhh=5)
```

```
Arguments type: <class 'dict'>
Arguments:  {'engineering': 5, 'it': 10, 'sales': 20, 'rrhh': 5}
```

Passing arbitrary arguments

- Or combine both solutions



```
def newBulding(city,*users,**parking):
    print("City variable type:",type(city))
    print("City: ",city)
    print("Users variable type:",type(users))
    print("Users: ",users)
    print("Parking variable type:",type(parking))
    print("Parking: ",parking)
```

```
newBulding("Madrid","Mia","Brian","Roman","Elena",engineering=5,it=10,sales=20,rrhh=5)
```

```
City variable type: <class 'str'>
City:  Madrid
Users variable type: <class 'tuple'>
Users:  ('Mia', 'Brian', 'Roman', 'Elena')
Parking variable type: <class 'dict'>
Parking:  {'engineering': 5, 'it': 10, 'sales': 20, 'rrhh': 5}
```

Ejercicios

- 1.- Programa que pide 3 números, num1, num2 y num3 llama a la función calculos() que devuelve el mayor, el menor y la media de los tres números y los muestra por pantalla en el programa principal.
- 2.- Programa que pide un nombre y llama a una función que muestra un mensaje de bienvenida particularizado para esa persona
- 3.- Programa que pide un número num1 y llama a la función factorial() que devuelve el factorial del número y lo muestra por pantalla en el programa principal.
- 4.- Programa que calcula el combinatorio de m sobre n.
- 5.- Programa que pide un número y llama a la función esPrimo() que devuelve verdadero si el número es primo y falso en caso contrario
- 6.- Programa que pide dos números y muestra por pantalla todos los números primos en ese intervalo
- 7.- Números amigos

Ámbito (scope) de la variables

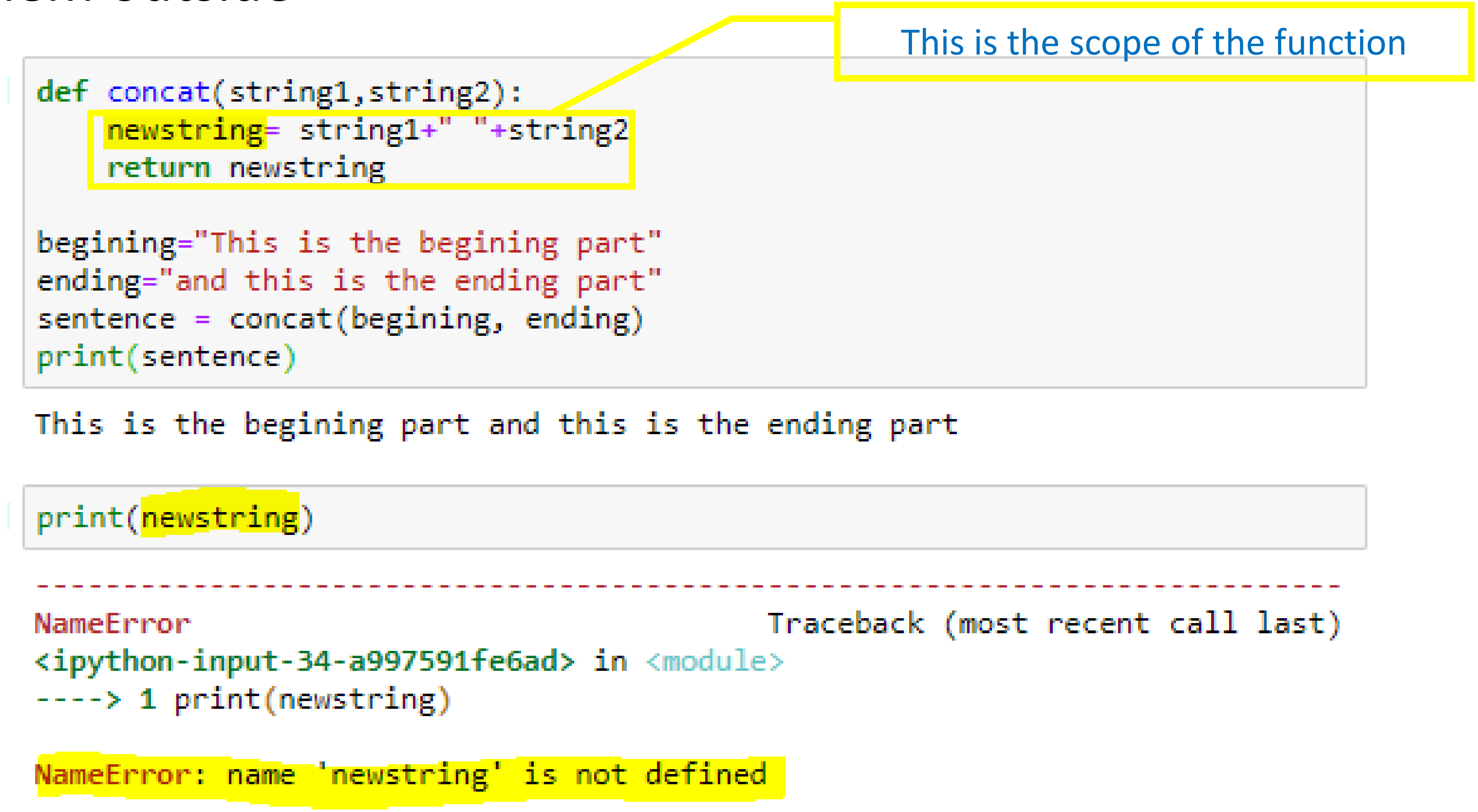
- El ámbito de una variable es la zona de programa donde puede ser utilizada.
    - Variable local: variable definida dentro de la función (incluido el main) y que tiene como ámbito de actuación (utilización) solo la propia función.
    - Variable global: variable definida fuera de todas las funciones, al principio del programa. Su ámbito de utilización es todo el programa, por lo que puede ser usada en cualquier función

Ámbito (scope) de la variables

- Diferentes niveles: el más alto es el programa principal, el siguiente nivel son las funciones incluidas en el programa principal y cada vez que hay una función incluida dentro de otra estaríamos bajando un nivel.
- Principios:
  - Cada variable pertenece a un ámbito determinado: programa principal o función
  - Las variables son completamente inaccesibles en los ámbitos superiores al ámbito al que pertenecen
  - las variables pueden ser accesibles o no en ámbitos inferiores al ámbito al que pertenecen

Functions Scope

- All the values defined inside the function's body are local. You cannot use them outside



This is the scope of the function

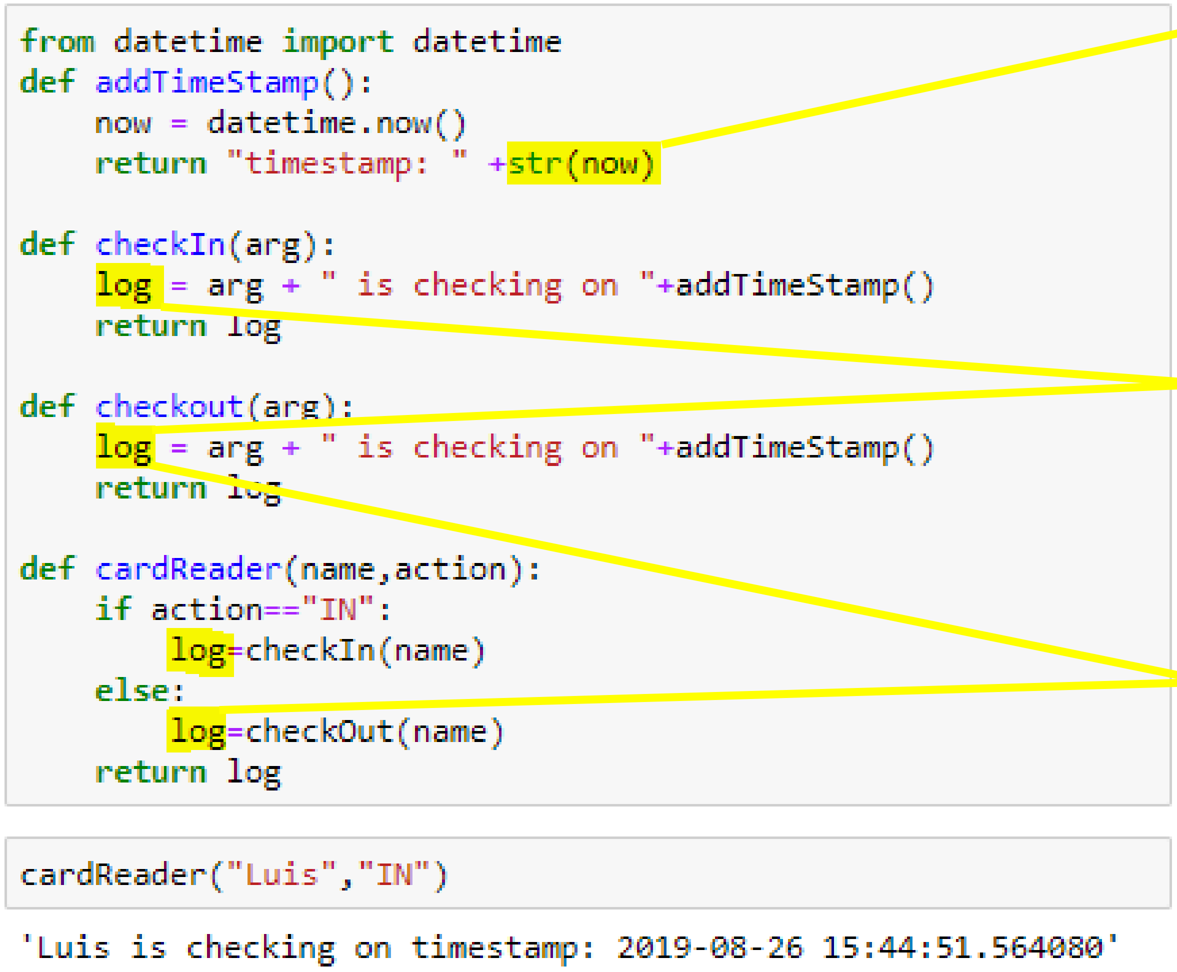
```
def concat(string1,string2):
    newstring= string1+" "+string2
    return newstring

begining="This is the begining part"
ending="and this is the ending part"
sentence = concat(begining, ending)
print(sentence)
```

```
This is the begining part and this is the ending part
```

```
print(newstring)
```

```
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
<ipython-input-34-a997591fe6ad> in <module>
----> 1 print(newstring)

NameError: name 'newstring' is not defined
```

Functions Scope



```
from datetime import datetime
def addTimeStamp():
    now = datetime.now()
    return "timestamp: " +str(now)

def checkIn(arg):
    log = arg + " is checking on "+addTimeStamp()
    return log

def checkout(arg):
    log = arg + " is checking on "+addTimeStamp()
    return log

def cardReader(name,action):
    if action=="IN":
        log=checkIn(name)
    else:
        log=checkOut(name)
    return log
```

```
cardReader("Luis","IN")
```

```
'Luis is checking on timestamp: 2019-08-26 15:44:51.564080'
```

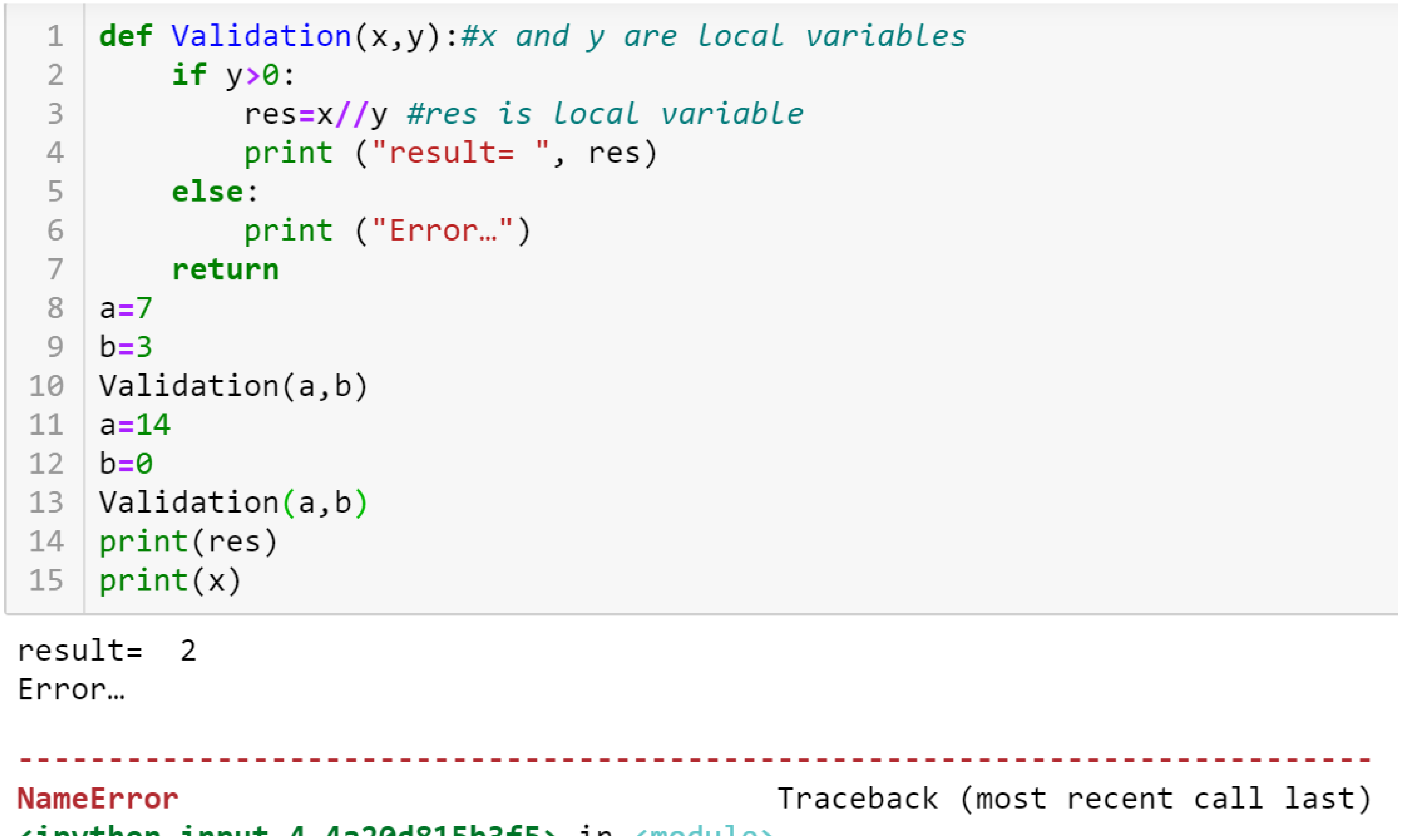
Cannot concatenate a datetime type with an string type without conversion

We can use the same variable name in different functions because scopes are different

An outer function can invoke an inner function that uses the same variable name because the scopes are different

Luis F. Sánchez Merchante

Functions Scope

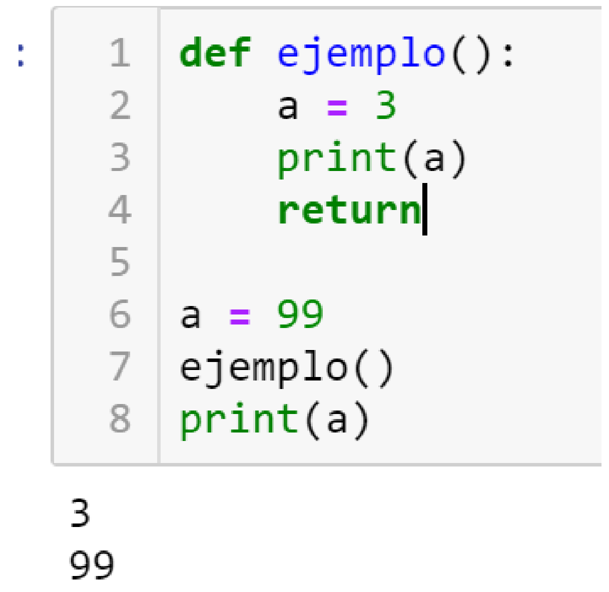


```python
def Validation(x,y):#x and y are local variables
    if y>0:
        res=x//y #res is local variable
        print ("result= ", res)
    else:
        print ("Error…")
    return
a=7
b=3
Validation(a,b)
a=14
b=0
Validation(a,b)
print(res)
print(x)
```

```
result=  2
Error…

---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
<ipython-input-4-4a20d815b3f5> in <module>
```

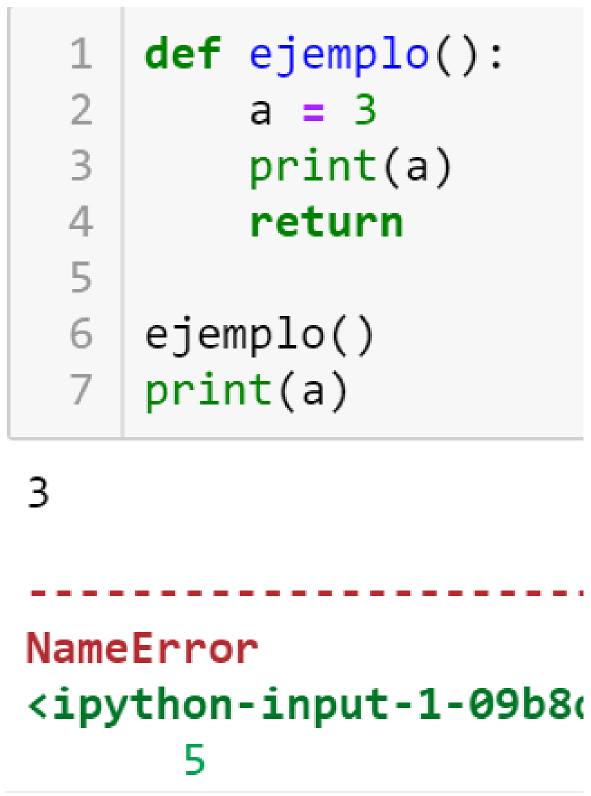
▶**Nota**: *res*, *x* and *y* are local variables of function *Validation()*

Functions Scope



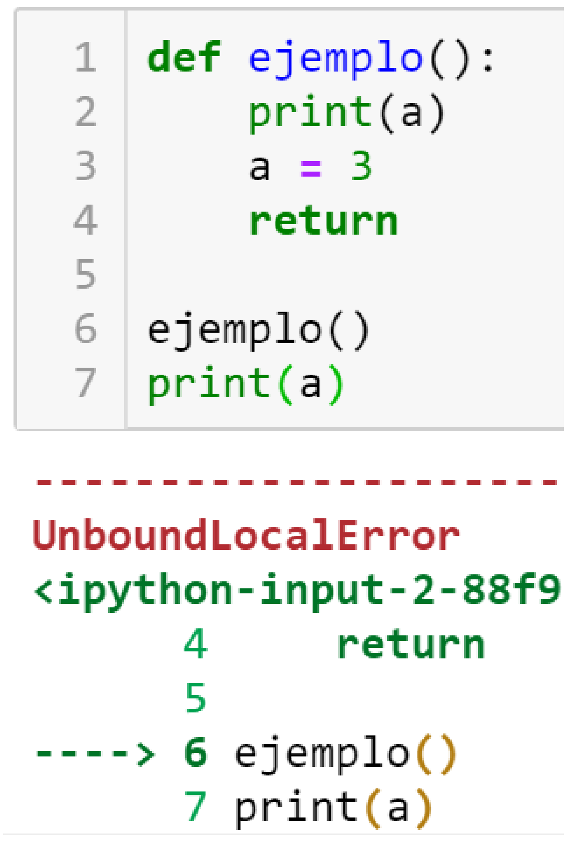
```python
def ejemplo():
    a = 3
    print(a)
    return

a = 99
ejemplo()
print(a)
```

```
3
99
```



```python
def ejemplo():
    a = 3
    print(a)
    return

ejemplo()
print(a)
```

```
3

---------------------
NameError
<ipython-input-1-09b8
      5
```



```python
def ejemplo():
    print(a)
    a = 3
    return

ejemplo()
print(a)
```

```
--------------------
UnboundLocalError
<ipython-input-2-88f9
      4     return
      5
----> 6 ejemplo()
      7 print(a)
```

Argumentos y devolución de valores

- En la mayoría de los lenguajes de programación, en los que las variables son contenedores donde se guardan valores, cuando se envía una variable como argumento en una llamada a una función suelen existir dos posiblidades:

1. Paso por valor o copia: se envía simplemente el valor de la variable, en cuyo caso la función no puede modificar la variable origen, pues la función sólo conoce una de su valor, pero no la variable que lo almacenaba.
2. Paso por referencia: se envía la dirección de memoria de la variable, en cuyo caso la función sí que puede modificar la variable, normalmente a través de punteros.

- En Python no se hace ni una cosa ni otra. En Python cuando se envía una variable como argumento en una llamada a una función lo que se envía es la referencia al objeto al que hace referencia la variable. Dependiendo de si el objeto es mutable o inmutable, la función podrá modificar o no el objeto.

Functions Scope

x is inmutable
LISTA mutable

```python
def example_passing(x,y):
    x=x**3
    y.append(10)
    print("\nValor de x en la función: ", x)
    print("Valor de y en la función: ", y)
    return
x=2
y=[2,4,6,8]
print("Valor de x en el programa: ", x)
print("Valor de y en el programa: ", y)
example_passing(x,y)
print("\nValor de x en el programa despues de llamar función: ", x)
print("Valor de y en el programa despues de llamar función: ", y)
```

```
Valor de x en el programa:  2
Valor de y en el programa:  [2, 4, 6, 8]

Valor de x en la función:  8
Valor de y en la función:  [2, 4, 6, 8, 10]

Valor de x en el programa despues de llamar función:  2
Valor de y en el programa despues de llamar función:  [2, 4, 6, 8, 10]
```

Note: The value of x is only changed in the function but the list has changed permanently.

Functions Scope

DICCIONARIO mutable

```
def passing_dic(student):
    student['telephone']=111111
    print("\nMuestro el diccionario MODIFICADO en la función ")
    print(student)
    return

student_data={}
str=input("Introduce student name:")
id=int(input("Introduce student id:"))
student_data['name']=str
student_data['ID']=id
print("\nMuestro el diccionario en el programa principal")
print(student_data)
passing_dic(student_data)
print("\nMuestro el diccionario en el programa principal")
print(student_data)
```

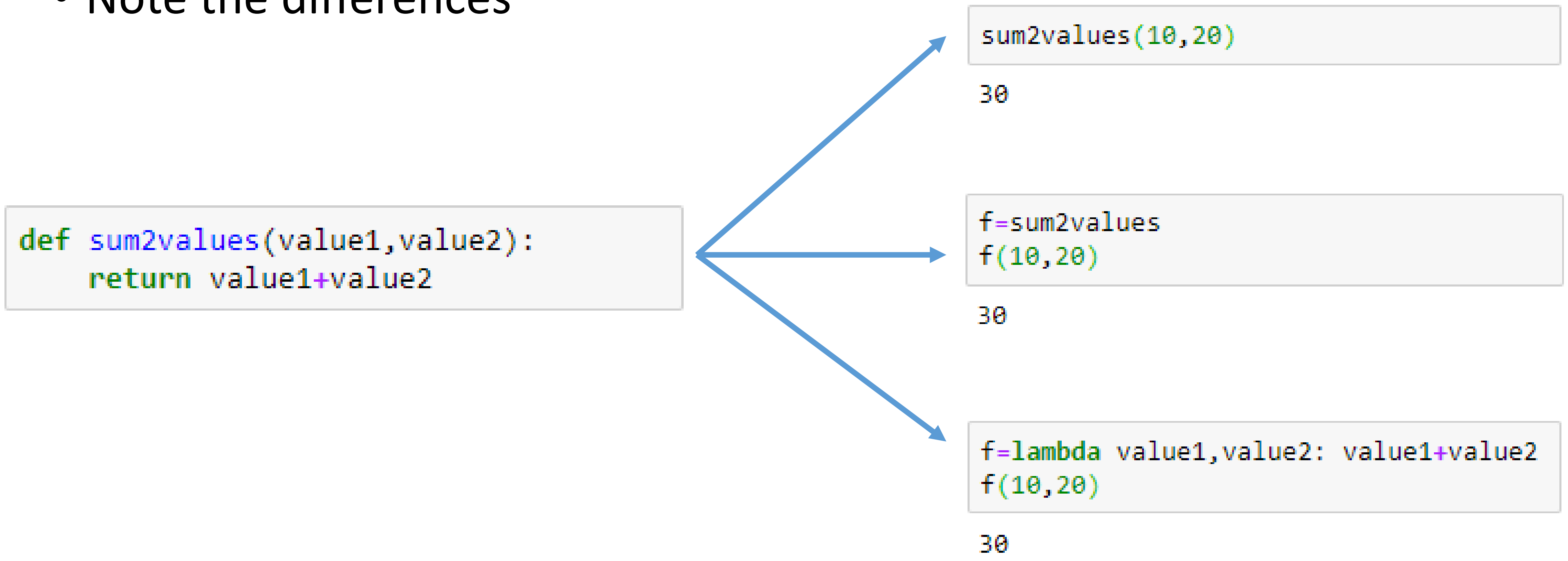
```
Introduce student name:Pepe Luis
Introduce student id:1234

Muestro el diccionario en el programa principal
{'name': 'Pepe Luis', 'ID': 1234}

Muestro el diccionario MODIFICADO en la función
{'name': 'Pepe Luis', 'ID': 1234, 'telephone': 111111}

Muestro el diccionario en el programa principal
{'name': 'Pepe Luis', 'ID': 1234, 'telephone': 111111}
```

Anonymous functions

- Are small functions
- They have no name
- Can only have a single expression
- Also known as LAMBDA functions
- Very common on MAP operations

Anonymous functions

- Note the differences



```
def sum2values(value1,value2):
    return value1+value2
```

```
sum2values(10,20)
```

```
30
```

```
f=sum2values
f(10,20)
```

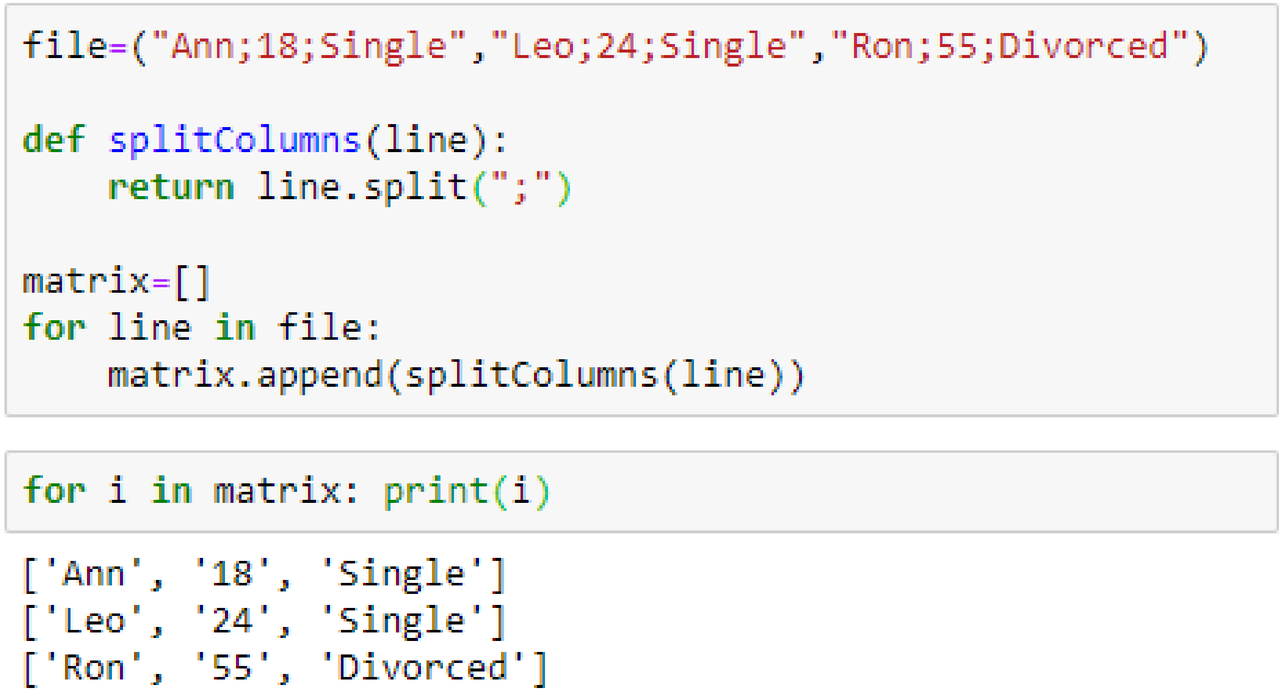
```
30
```

```
f=lambda value1,value2: value1+value2
f(10,20)
```

```
30
```

Anonymous functions

- Makes MAP operations straightforward. Mapping means applying the same transformation to all the elements of a collection



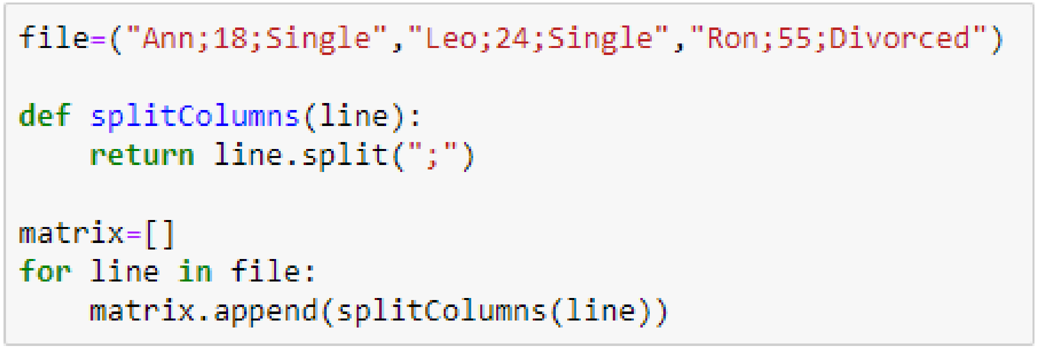
```python
file=("Ann;18;Single","Leo;24;Single","Ron;55;Divorced")

def splitColumns(line):
    return line.split(";")

matrix=[]
for line in file:
    matrix.append(splitColumns(line))
```

```python
for i in matrix: print(i)
```

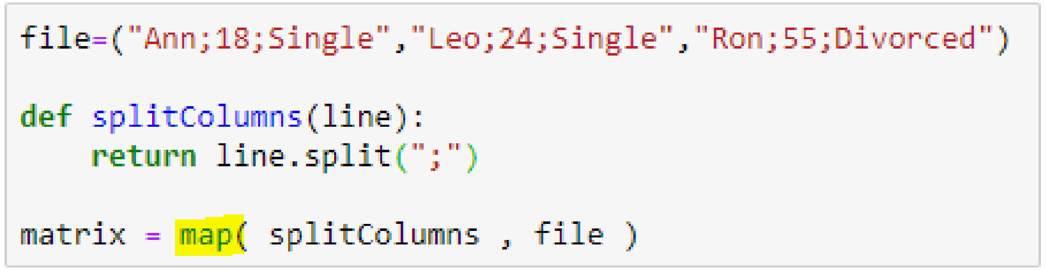
```
['Ann', '18', 'Single']
['Leo', '24', 'Single']
['Ron', '55', 'Divorced']
```

Luis F. Sánchez Merchante

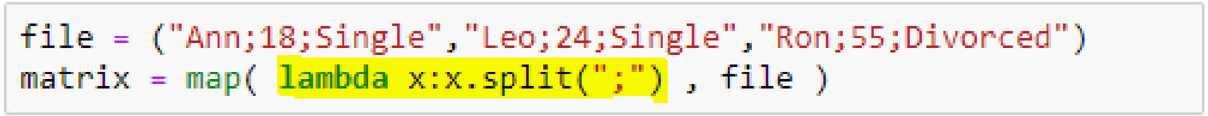
Anonymous functions



```
file=("Ann;18;Single","Leo;24;Single","Ron;55;Divorced")

def splitColumns(line):
    return line.split(";")

matrix=[]
for line in file:
    matrix.append(splitColumns(line))
```



```
file=("Ann;18;Single","Leo;24;Single","Ron;55;Divorced")

def splitColumns(line):
    return line.split(";")

matrix = map( splitColumns , file )
```



```
file = ("Ann;18;Single","Leo;24;Single","Ron;55;Divorced")
matrix = map( lambda x:x.split(";") , file )
```

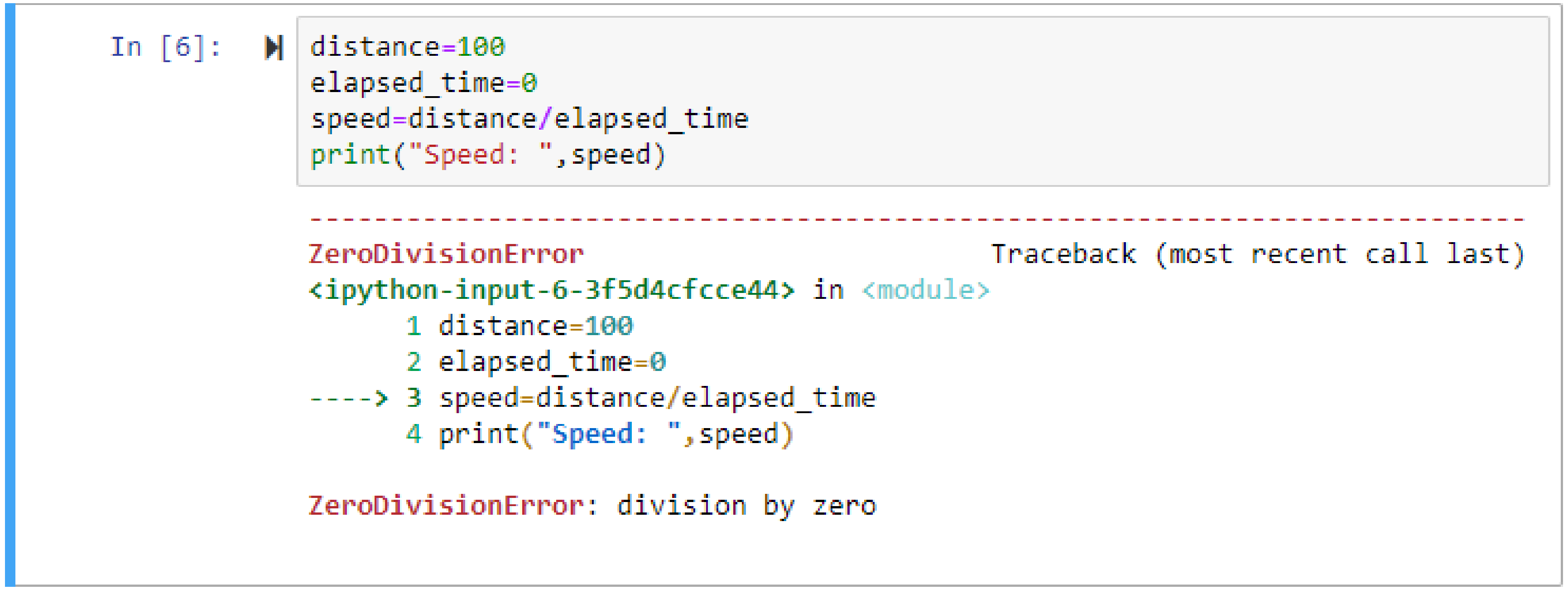
This is the most common way of processing extremely large collections on Big Data infrastructures

Handling exceptions

- Whenever a runtime error occurs, it creates an exception
- The default behaviour is halting the program and display a message
- No critical on amateur codes
- Mandatory on professional services

Handling exceptions

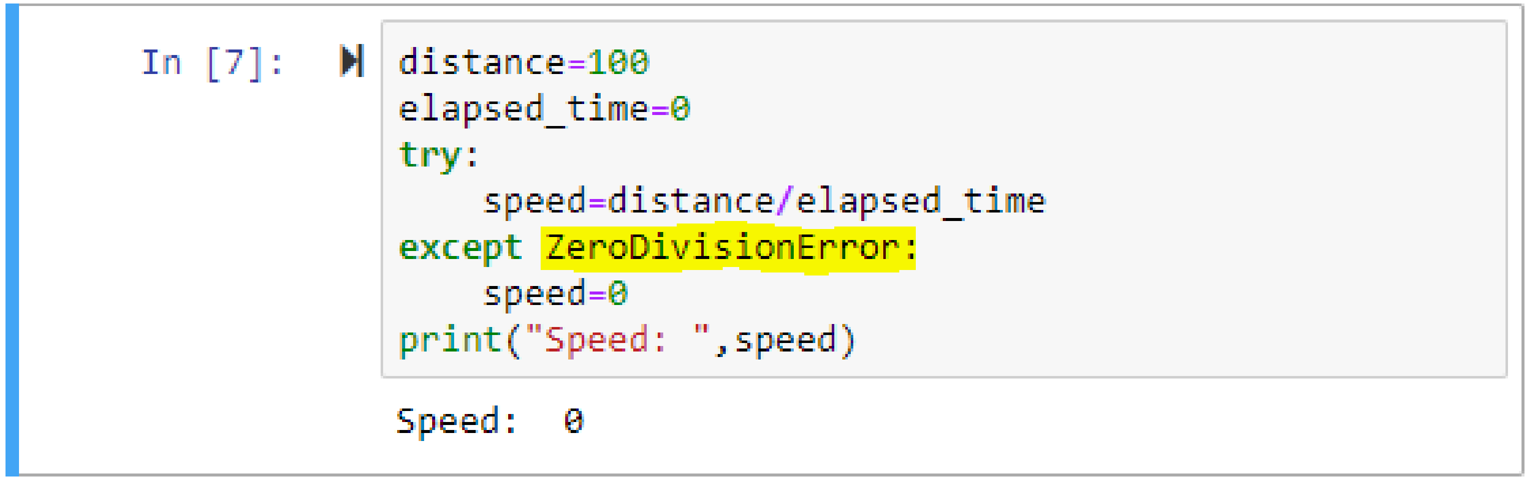
- Why this code launch an exception?



```
In [6]:   distance=100
          elapsed_time=0
          speed=distance/elapsed_time
          print("Speed: ",speed)

---------------------------------------------------------------------------
ZeroDivisionError                         Traceback (most recent call last)
<ipython-input-6-3f5d4cfcce44> in <module>
      1 distance=100
      2 elapsed_time=0
----> 3 speed=distance/elapsed_time
      4 print("Speed: ",speed)

ZeroDivisionError: division by zero
```

Handling exceptions

- How do we deal with it?
- Use try/except statements
  - try: code to "protect"
  - except: what to do if an exception is thrown



```
In [7]:   distance=100
          elapsed_time=0
          try:
              speed=distance/elapsed_time
          except ZeroDivisionError:
              speed=0
          print("Speed: ",speed)

          Speed:  0
```

Handling exceptions

- Remember this code?

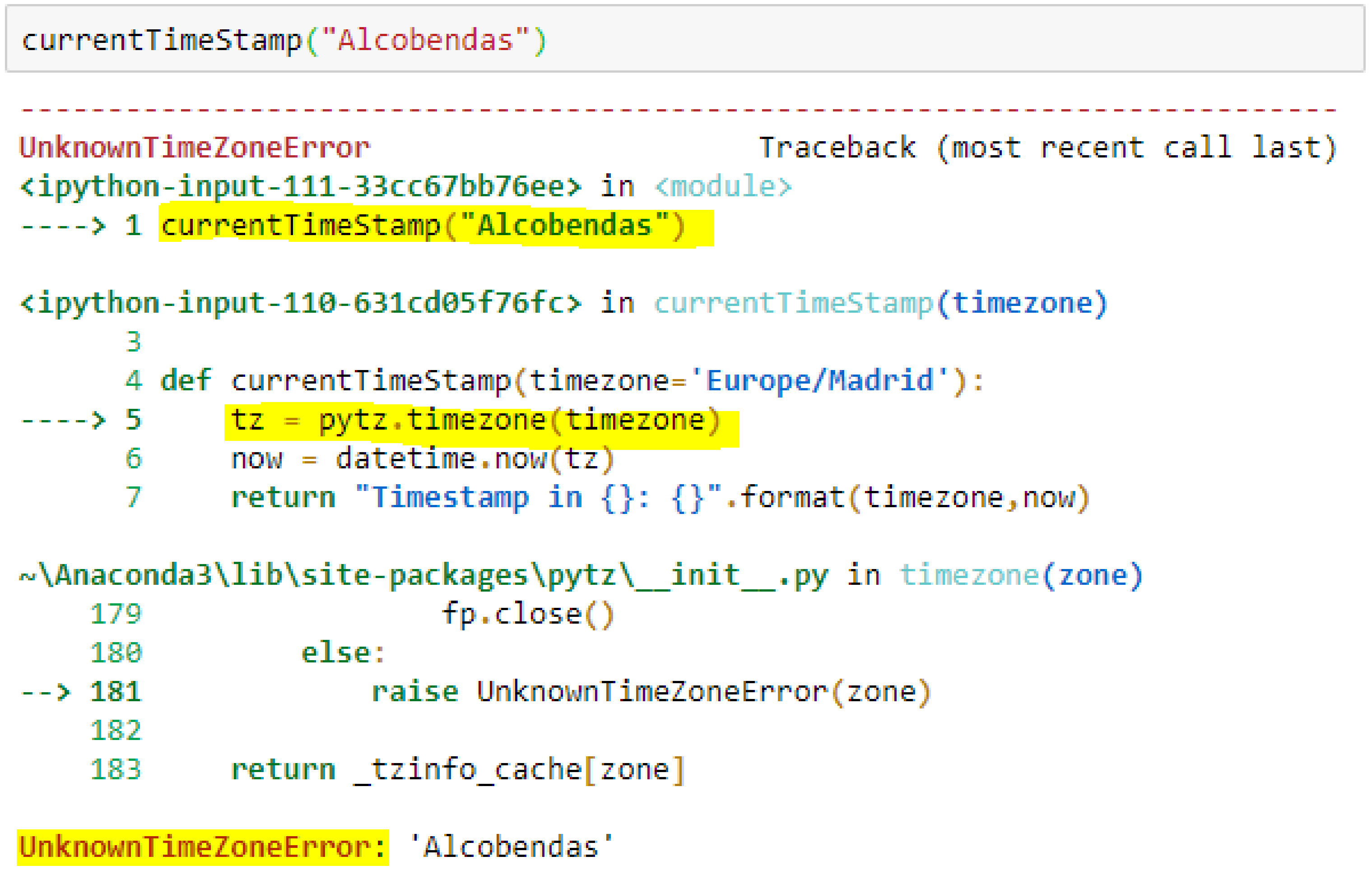
```
from datetime import datetime
import pytz

def currentTimeStamp(timezone='Europe/Madrid'):
    tz = pytz.timezone(timezone)
    now = datetime.now(tz)
    return "Timestamp in {}: {}".format(timezone,now)
```

- What would happen if we run this statement?

```
currentTimeStamp("Alcobendas")
```

Handling exceptions

- This time zone does not exists
- The function from library pytz raises an exception
- The function "currentTimeStamp" does not know what to do with it



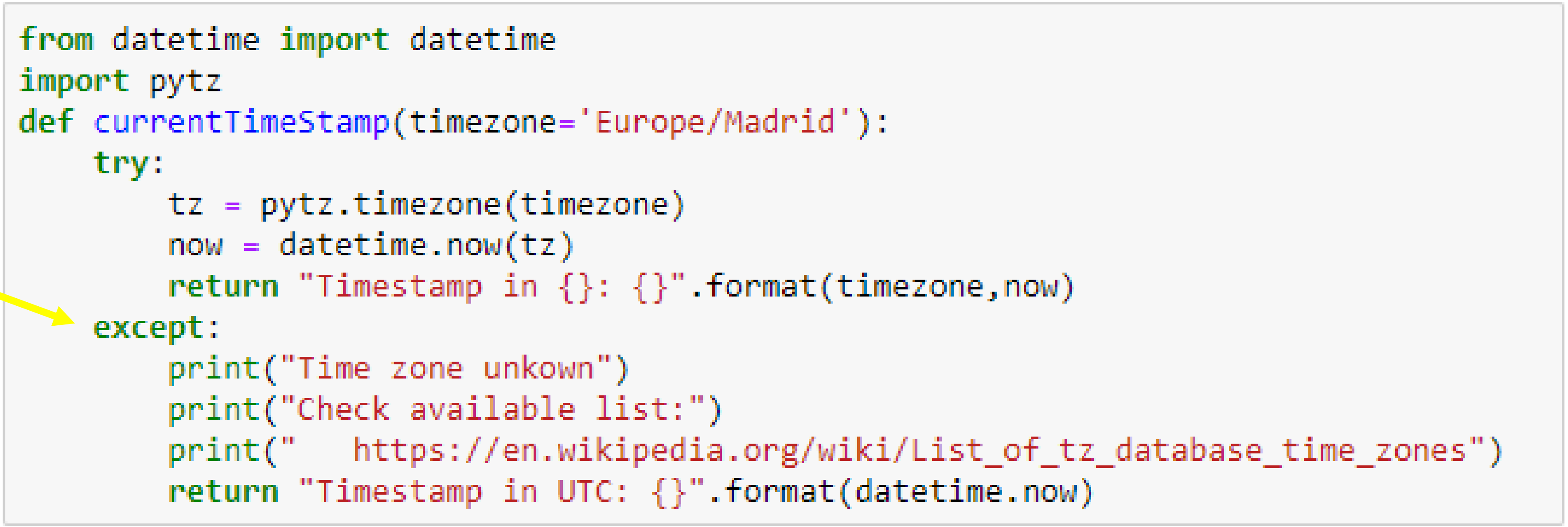
```
currentTimeStamp("Alcobendas")
```

```
---------------------------------------------------------------------------
UnknownTimeZoneError                      Traceback (most recent call last)
<ipython-input-111-33cc67bb76ee> in <module>
----> 1 currentTimeStamp("Alcobendas")

<ipython-input-110-631cd05f76fc> in currentTimeStamp(timezone)
      3 
      4 def currentTimeStamp(timezone='Europe/Madrid'):
----> 5     tz = pytz.timezone(timezone)
      6     now = datetime.now(tz)
      7     return "Timestamp in {}: {}".format(timezone,now)

~\Anaconda3\lib\site-packages\pytz\__init__.py in timezone(zone)
    179                 fp.close()
    180             else:
--> 181                 raise UnknownTimeZoneError(zone)
    182 
    183     return _tzinfo_cache[zone]

UnknownTimeZoneError: 'Alcobendas'
```

Handling exceptions

- We can capture specific exceptions or capture any of them

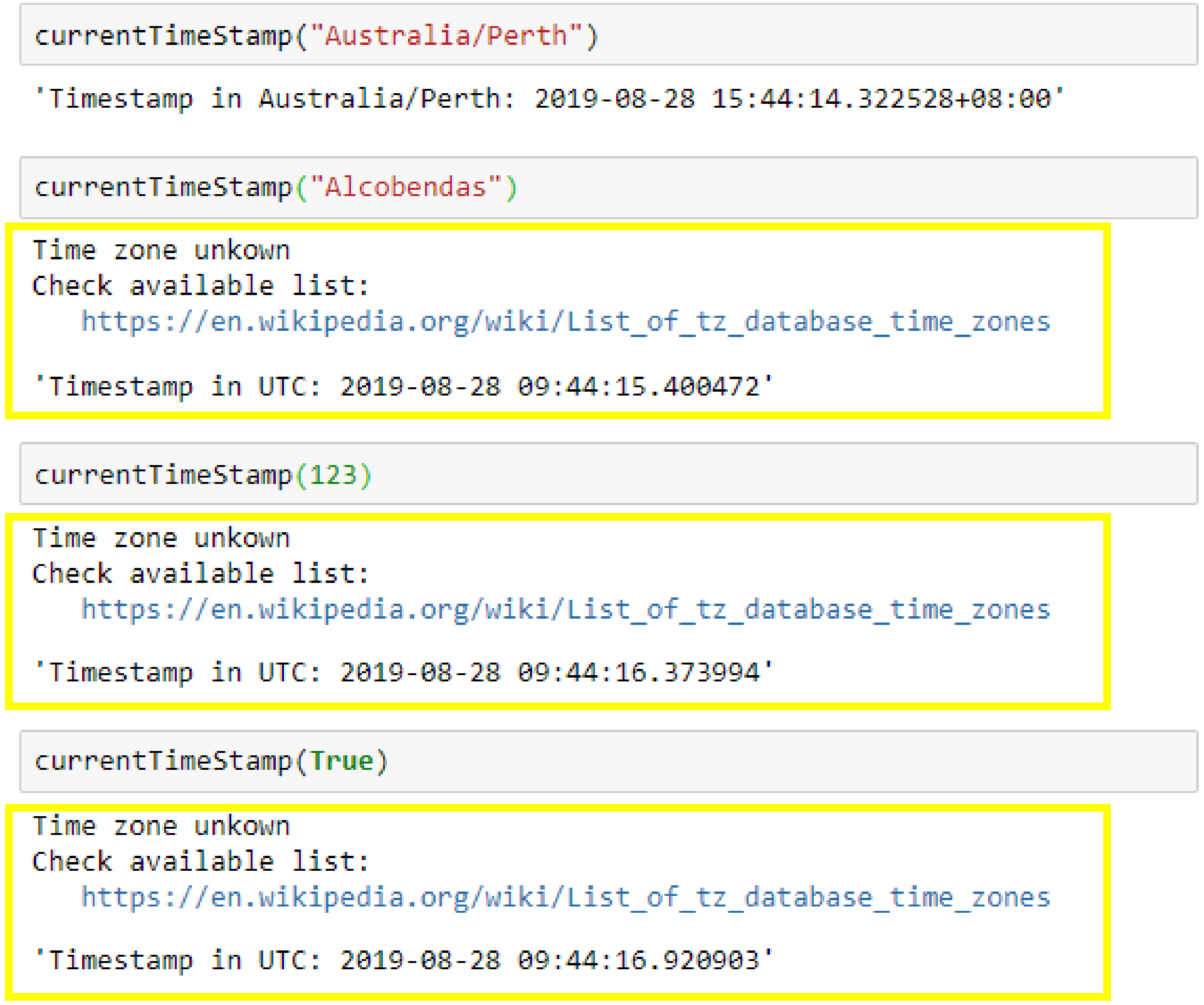
Note that we don't specify the Exception



```
from datetime import datetime
import pytz
def currentTimeStamp(timezone='Europe/Madrid'):
    try:
        tz = pytz.timezone(timezone)
        now = datetime.now(tz)
        return "Timestamp in {}: {}".format(timezone,now)
    except:
        print("Time zone unkown")
        print("Check available list:")
        print("   https://en.wikipedia.org/wiki/List_of_tz_database_time_zones")
        return "Timestamp in UTC: {}".format(datetime.now)
```

Handling exceptions

- When the input time zone does not exists, now the code knows what to do
- It will never fail



```
currentTimeStamp("Australia/Perth")
```

```
'Timestamp in Australia/Perth: 2019-08-28 15:44:14.322528+08:00'
```

```
currentTimeStamp("Alcobendas")
```

```
Time zone unkown
Check available list:
   https://en.wikipedia.org/wiki/List_of_tz_database_time_zones

'Timestamp in UTC: 2019-08-28 09:44:15.400472'
```

```
currentTimeStamp(123)
```

```
Time zone unkown
Check available list:
   https://en.wikipedia.org/wiki/List_of_tz_database_time_zones

'Timestamp in UTC: 2019-08-28 09:44:16.373994'
```

```
currentTimeStamp(True)
```

```
Time zone unkown
Check available list:
   https://en.wikipedia.org/wiki/List_of_tz_database_time_zones

'Timestamp in UTC: 2019-08-28 09:44:16.920903'
```

Custom Exceptions

- There exists a limited number of exceptions
- We can implement our own

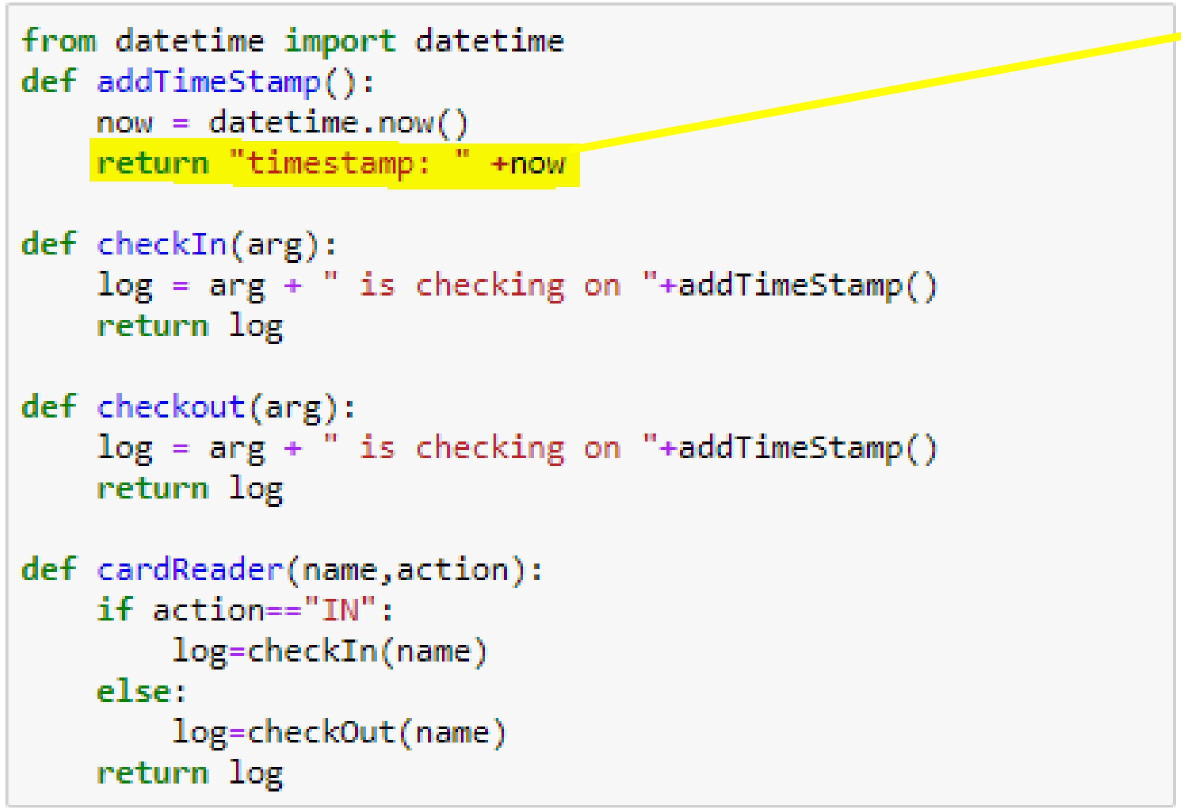
Create new Exception

```python
class RetrialsExceeded(Exception):
    pass
```

Launch new Exception

```python
counter=0
while True:
    password=input("Chose password: ")
    if not(password.isalpha() or password.isnumeric()):
        print("Password chosen")
        break
    else:
        counter+=1
        print(counter)
        if counter == 3: raise RetrialsExceeded("Number of retrials exceeded")
```

Functions and their error messages



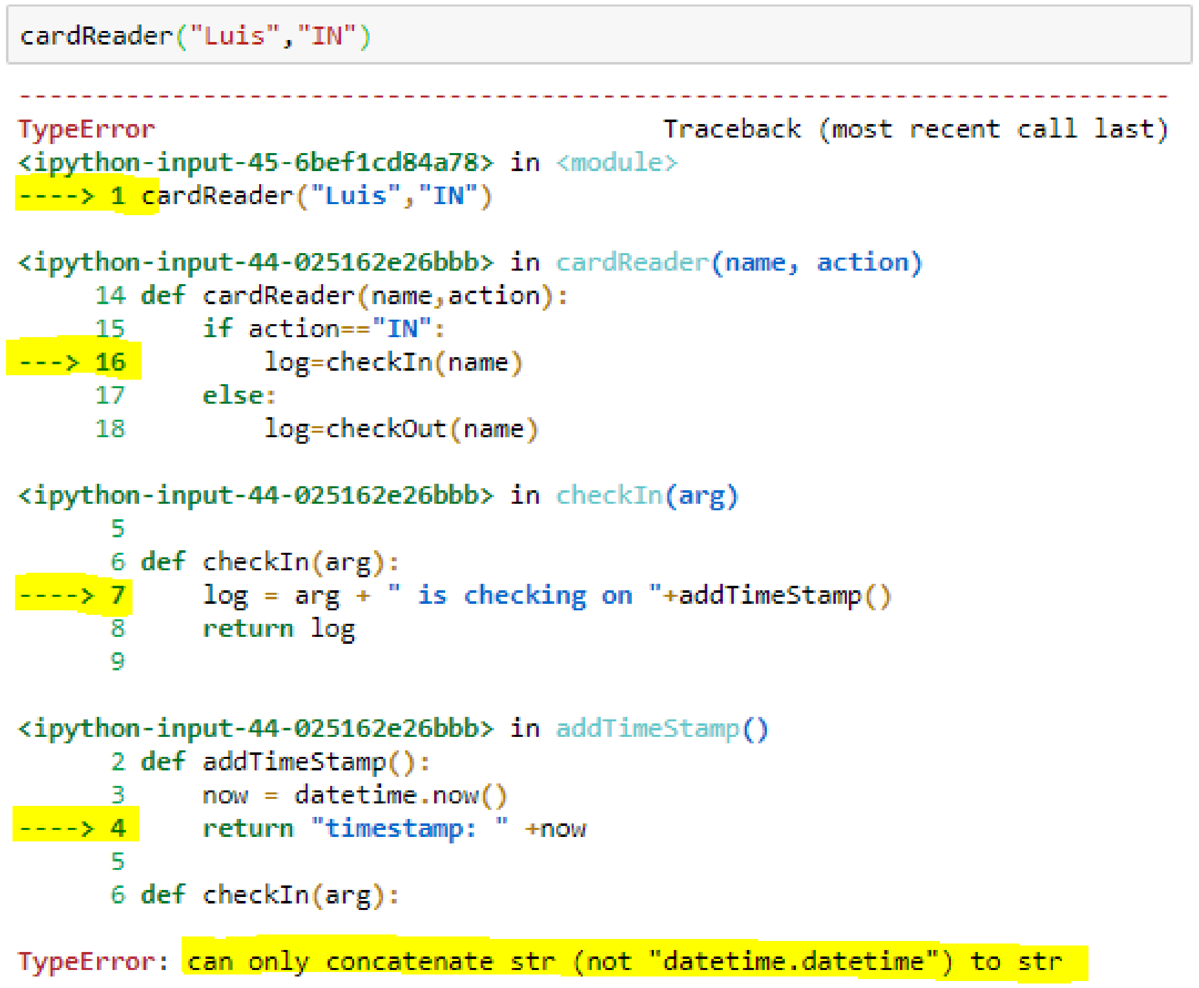
```
from datetime import datetime
def addTimeStamp():
    now = datetime.now()
    return "timestamp: " +now

def checkIn(arg):
    log = arg + " is checking on "+addTimeStamp()
    return log

def checkout(arg):
    log = arg + " is checking on "+addTimeStamp()
    return log

def cardReader(name,action):
    if action=="IN":
        log=checkIn(name)
    else:
        log=checkOut(name)
    return log
```

This concatenation will fail

Luis F. Sánchez Merchante

Functions and their error messages

- The error trace shows all the functions that were “active” during the failure (called TRACEBACK)
- The inner trace (the bottom one) shows the real failure



```
cardReader("Luis","IN")
```

```
---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
<ipython-input-45-6bef1cd84a78> in <module>
----> 1 cardReader("Luis","IN")

<ipython-input-44-025162e26bbb> in cardReader(name, action)
     14 def cardReader(name,action):
     15     if action=="IN":
---> 16         log=checkIn(name)
     17     else:
     18         log=checkOut(name)

<ipython-input-44-025162e26bbb> in checkIn(arg)
      5
      6 def checkIn(arg):
----> 7     log = arg + " is checking on "+addTimeStamp()
      8     return log
      9

<ipython-input-44-025162e26bbb> in addTimeStamp()
      2 def addTimeStamp():
      3     now = datetime.now()
----> 4     return "timestamp: " +now
      5
      6 def checkIn(arg):

TypeError: can only concatenate str (not "datetime.datetime") to str
```

Luis F. Sánchez Merchante

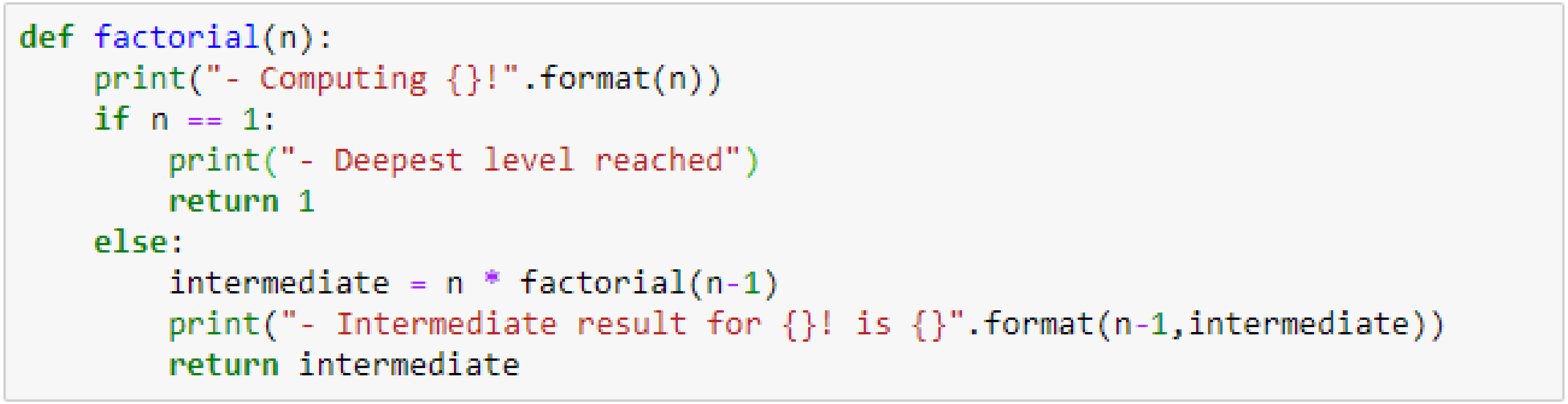
Recursion

- Functions can be called from within another
- But a function can also call itself
- Beware of RECURSION and infinity interactions
- That can make complex functions very compact but can be extremely difficult to debug

Recursion

- Compute N! (read N factorial)

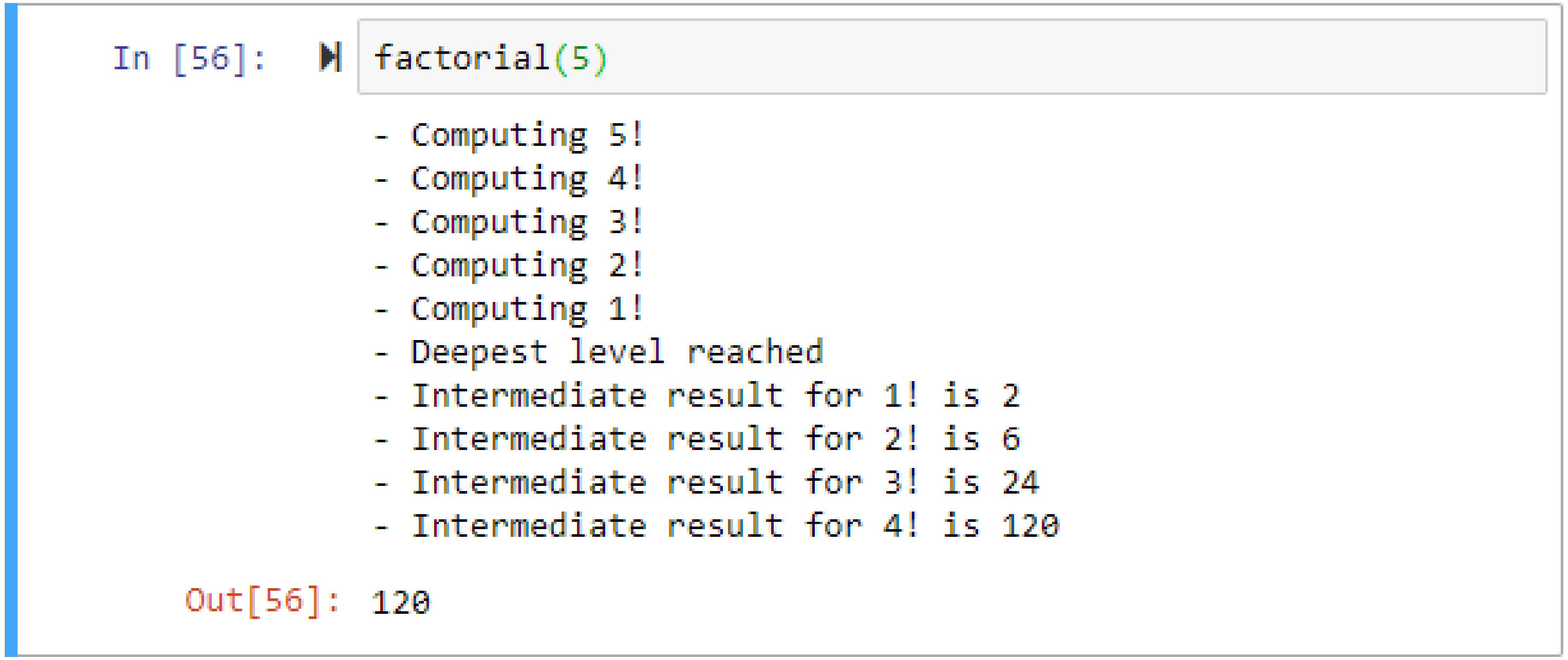
$$N! = N * (N-1) * (N-2) * \cdots * 1$$



```python
def factorial(n):
    print("- Computing {}!".format(n))
    if n == 1:
        print("- Deepest level reached")
        return 1
    else:
        intermediate = n * factorial(n-1)
        print("- Intermediate result for {}! is {}".format(n-1,intermediate))
        return intermediate
```

Recursion

- Compute N! (read N factorial)

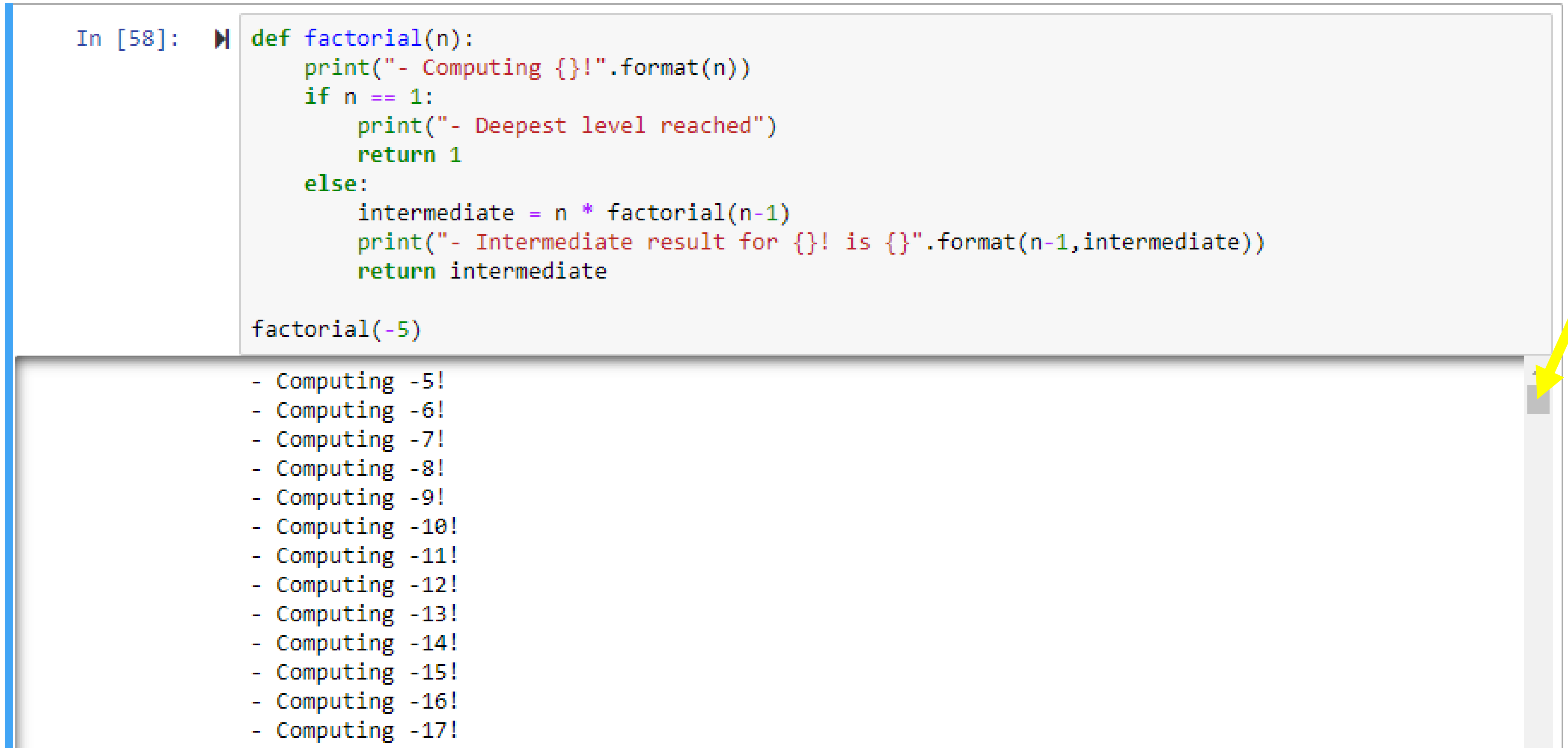


```
In [56]:    factorial(5)

            - Computing 5!
            - Computing 4!
            - Computing 3!
            - Computing 2!
            - Computing 1!
            - Deepest level reached
            - Intermediate result for 1! is 2
            - Intermediate result for 2! is 6
            - Intermediate result for 3! is 24
            - Intermediate result for 4! is 120

Out[56]:    120
```

Recursion

What would happen if we run factorial(-5)?

Recursion



```
In [58]:   def factorial(n):
               print("- Computing {}!".format(n))
               if n == 1:
                   print("- Deepest level reached")
                   return 1
               else:
                   intermediate = n * factorial(n-1)
                   print("- Intermediate result for {}! is {}".format(n-1,intermediate))
                   return intermediate

           factorial(-5)
```

```
- Computing -5!
- Computing -6!
- Computing -7!
- Computing -8!
- Computing -9!
- Computing -10!
- Computing -11!
- Computing -12!
- Computing -13!
- Computing -14!
- Computing -15!
- Computing -16!
- Computing -17!
```

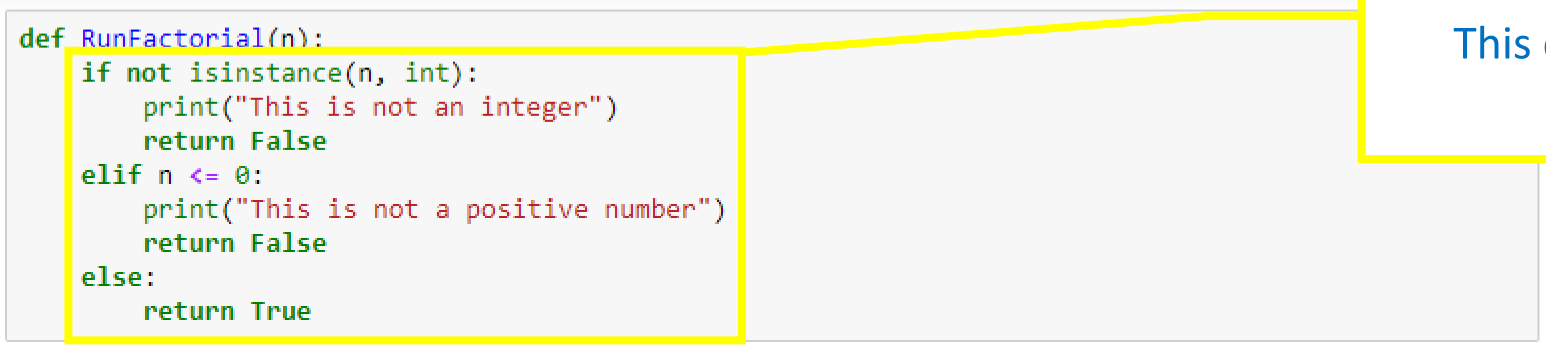
To stop this we need to reboot the kernel

Luis F. Sánchez Merchante

Boolean functions

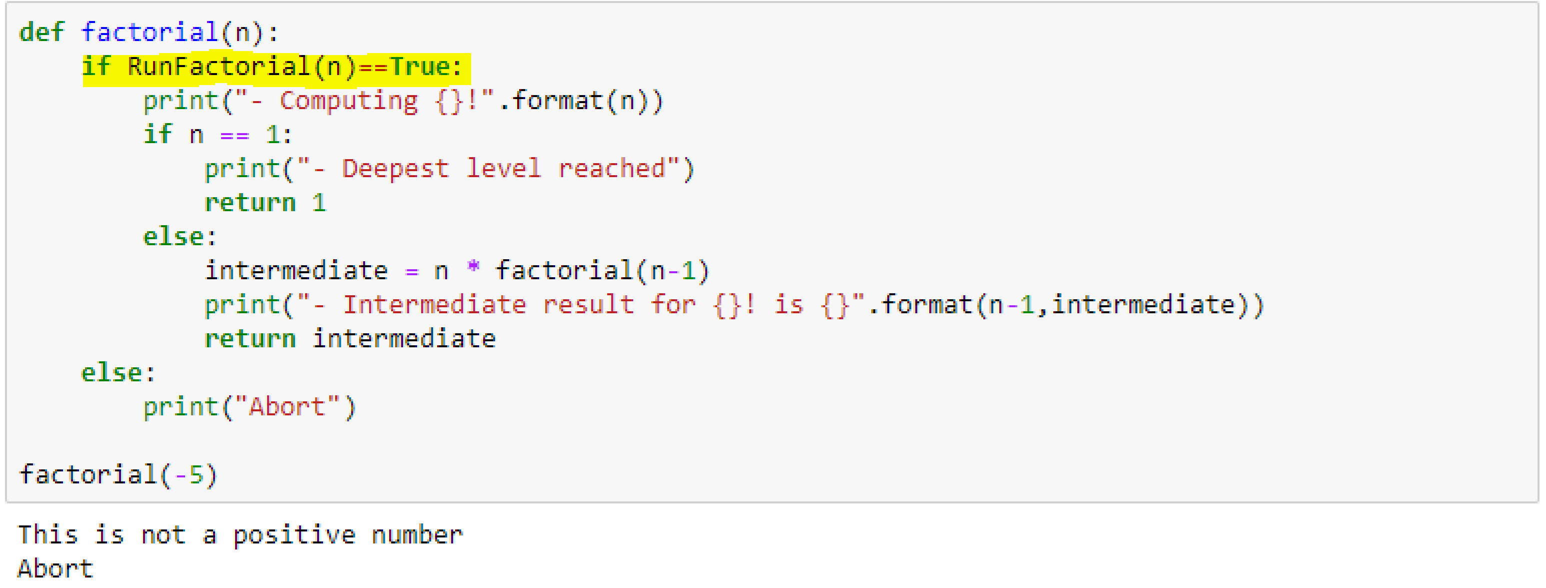
- Functions can return Boolean values
- This is commonly used for hiding complicated tests
- We can solve factorial(-5) if we implement some verifications before running the function

Boolean functions



```
def RunFactorial(n):
    if not isinstance(n, int):
        print("This is not an integer")
        return False
    elif n <= 0:
        print("This is not a positive number")
        return False
    else:
        return True
```

This code only returns TRUE when the number is an integer > 0



```
def factorial(n):
    if RunFactorial(n)==True:
        print("- Computing {}!".format(n))
        if n == 1:
            print("- Deepest level reached")
            return 1
        else:
            intermediate = n * factorial(n-1)
            print("- Intermediate result for {}! is {}".format(n-1,intermediate))
            return intermediate
    else:
        print("Abort")

factorial(-5)
```

```
This is not a positive number
Abort
```

Luis F. Sánchez Merchante