CS65: Introduction to Computer Science

Built-in functions
Control flow during function call
Scope of a variable

September 08, 2022

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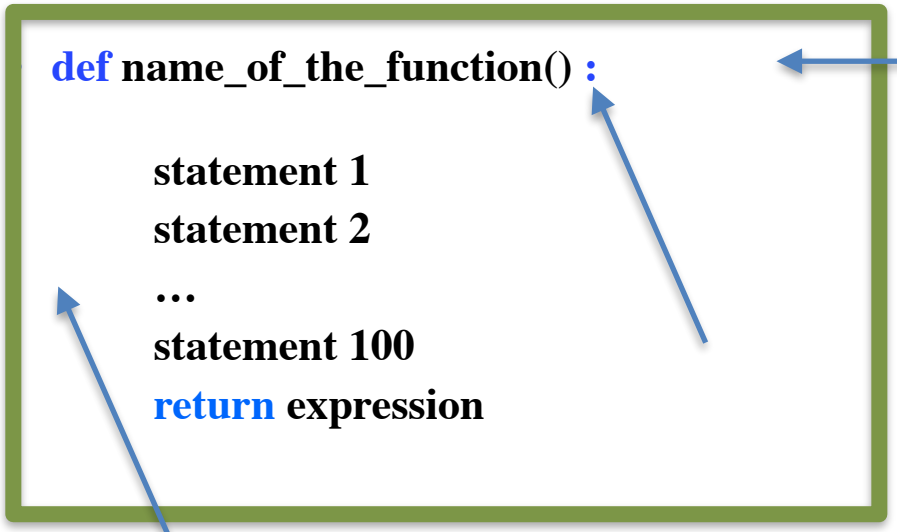
Recap

- Functions — a new concept
  - User defined functions vs built-in functions

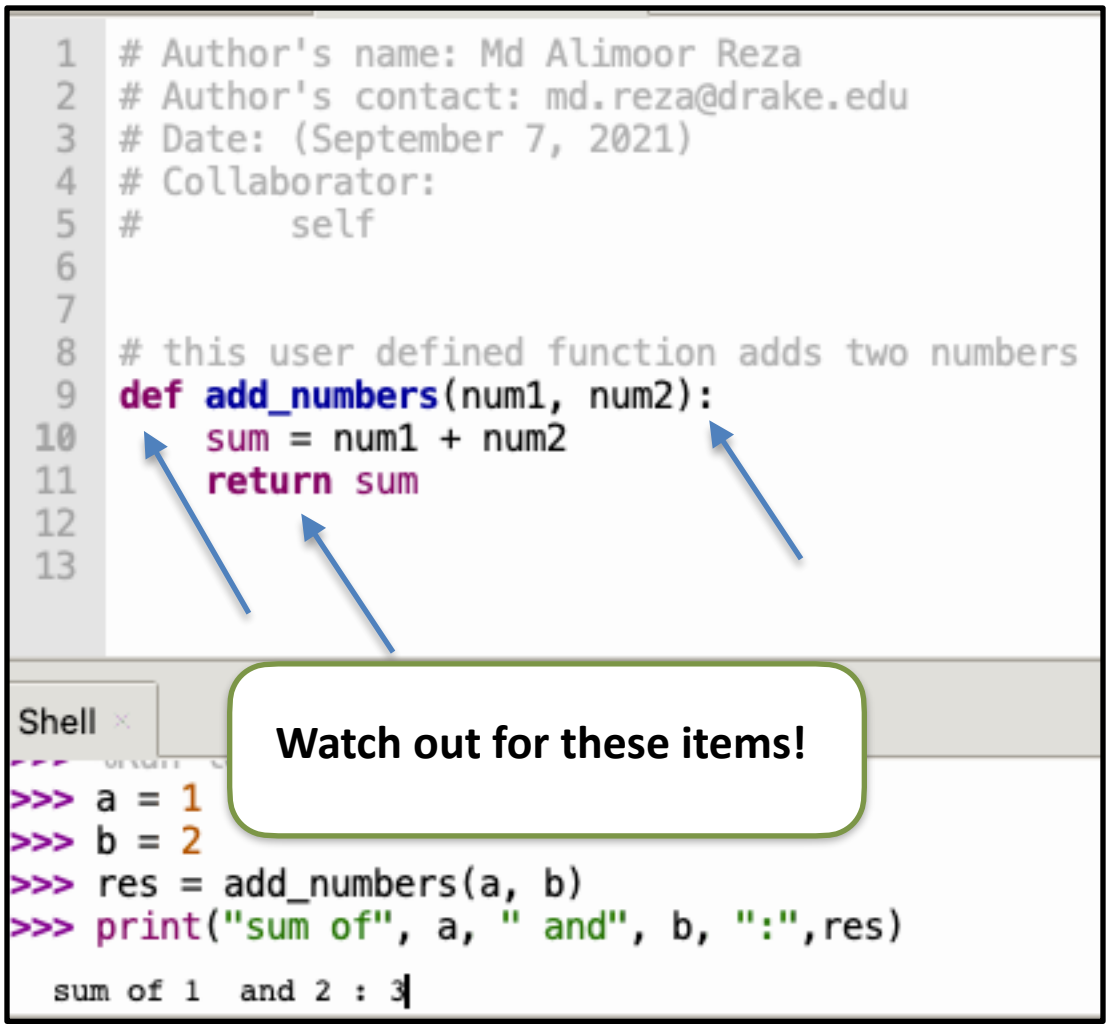
- User defined functions
  - defining function: what statements it will execute
  - calling function: invoke/execute the defined body

Recap: Define a function with no parameters



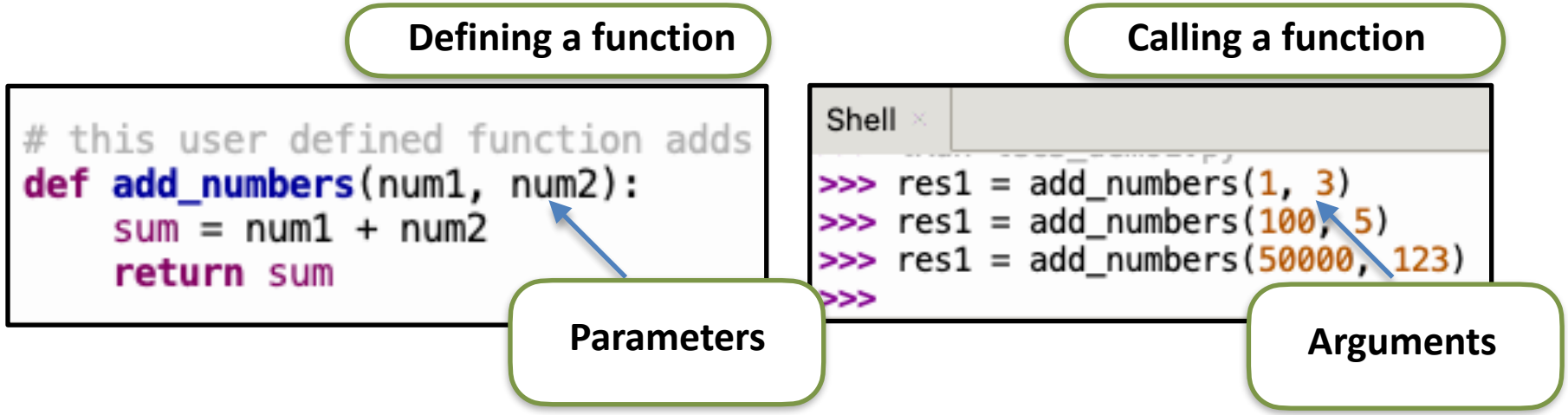
- **name_of_the_function**: a meaningful name denoting the task with a preceding **def** keyword
- **statements**: a sequence of python instructions to be executed followed by an optional **return** keyword with expression(s)
  - without a **return** statement function implicitly returns **None**
- Notice: indention (eg, tab) is required to define a **function** and also notice at the end of the condition expression there is a **colon**

Recap: user defined function example



Recap: Calling a Function

- **name_of_the_function**(*argument*$_1$, *argument*$_2$, …, *argument*$_4$)



- Function **calling name** should match function **definition name**
- Use *values*, *expression*, or *variables* to the **parameters** of the function
  - **arguments** should match **parameters**: one-to-one mapping
- When you call the function the execution gets transferred to the statements inside the function definition

Demo: calling with values

```
1  # Author's name: Md Alimoor Reza
2  # Author's contact: md.reza@drake.edu
3  # Date: (September 7, 2021)
4  # Collaborator:
5  #       self
6
7
8  # this user defined function adds two numbers
9  def add_numbers(num1, num2):
10     sum = num1 + num2
11     print("add function: called with num1=%d num2=%d and res=%d"%(num1,num2, num1+num2))
12     return sum
13
14 def sub_numbers(num1, num2):
15     sub = num1 - num2
16     print("subtract function: called with num1=%d num2=%d and res=%d"%(num1,num2, num1-num2))
17     return sub
18
19 def mul_numbers(a,b):
20     # Your task
21     return
22 def div_numbers(a,b):
23     # Your task
24     return
25
```

Defining a function

Calling a function

```
Shell
Python 3.7.9 (bundled)
>>> %Run lec3_demo2.py
>>> sub = sub_numbers(10, 4)

  subtract function: called with num1=10 num2=4 and res=6

>>> print("result of subtraction from %d to %d is %d"%(10,4, sub))

  result of subtraction from 10 to 4 is 6
```

Demo: calling with variables

```
1  # Author's name: Md Alimoor Reza
2  # Author's contact: md.reza@drake.edu
3  # Date: (September 7, 2021)
4  # Collaborator:
5  #       self
6
7
8  # this user defined function adds two numbers
9  def add_numbers(num1, num2):
10     sum = num1 + num2
11     print("add function: called with num1=%d num2=%d and res=%d"%(num1,num2, num1+num2))
12     return sum
13
14 def sub_numbers(num1, num2):
15     sub = num1 - num2
16     print("subtract function: called with num1=%d num2=%d and res=%d"%(num1,num2, num1-num2))
17     return sub
18
19 def mul_numbers(a,b):
20     # Your task
21     return
22 def div_numbers(a,b):
23     # Your task
24     return
25
```

Calling the same function with variables

Shell

```
>>> a = 10
>>> b = 4
>>> sub = sub_numbers(a, b)
  subtract function: called with num1=10 num2=4 and res=6
>>> print("result of subtraction from %d to %d is %d"%(a,b, sub))
  result of subtraction from 10 to 4 is 6
```

Demo: calling a function multiple times

```
1  # Author's name: Md Alimoor Reza
2  # Author's contact: md.reza@drake.edu
3  # Date: (September 7, 2021)
4  # Collaborator:
5  #       self
6
7
8  # this user defined function adds two numbers
9  def add_numbers(num1, num2):
10     sum = num1 + num2
11     print("add function: called with num1=%d num2=%d and res=%d"%(num1,num2, num1+num2))
12     return sum
13
14 def sub_numbers(num1, num2):
15     sub = num1 - num2
16     print("subtract function: called with num1=%d num2=%d and res=%d"%(num1,num2, num1-num2))
17     return sub
18
```

Shell

```
  result of subtraction from 10 to 4 is 6

>>>

Python 3.7.9 (bundled)
>>> %Run lec3_demo2.py
>>> sub1 = sub_numbers(10, 4)
  subtract function: called with num1=10 num2=4 and res=6
>>> sub2 = sub_numbers(10, 5)
  subtract function: called with num1=10 num2=5 and res=5
>>> sub3 = sub_numbers(10, 6)
  subtract function: called with num1=10 num2=6 and res=4
>>>
```

Calling the function multiple times

Exercise 1: finish the rest and call them with various arguments

```
1  # Author's name: Md Alimoor Reza
2  # Author's contact: md.reza@drake.edu
3  # Date: (September 7, 2021)
4  # Collaborator:
5  #       self
6
7
8  # this user defined function adds two numbers
9  def add_numbers(num1, num2):
10     sum = num1 + num2
11     print("add function: called with num1=%d num2=%d and res=%d"%(num1,num2, num1+num2))
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14 def sub_numbers(num1, num2):
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16     print("subtract function: called with num1=%d num2=%d and res=%d"%(num1,num2, num1-num2))
17     return sub
18
19 def mul_numbers(a,b):
20     # Your task
21     return
22 def div_numbers(a,b):
23     # Your task
24     return
25
```

Additional Topics for Today

- Built-in functions in Python
  - eg, ***input***() receiving input from user
  - No need to define, just call

- Control flow during function call
  - Debugging features of Thonny
  - Step-by-step execution of your program

- Scope of a variable
  - Global scope vs local scope

Built-in functions in Python

- You **do not** need to **define** the function; just call it
- We have already used 3 built-in functions:

- ***print***()

```
>>> print("hello world.")
  hello world.
```

- ***input***()

```
>>> a = input("please enter a numbrer ")
  please enter a numbrer 13
>>> print("enterend number is",a)
  enterend number is 13
```

- ***int***()

```
>>> b = 12.56
>>> c = int(b)
>>> print("converted integer number is ", c)
  converted integer number is  12
```

Built-in functions in Python

- If you want to use not so commonly available built-in functions, those built-in functions need to be imported using import keyword from a library
  - library also called a module
- Import the module before using it usually at the top of your python file
- Call function using *module_name* . *function_name*

```
import math

value_of_pi = math.pi
```

Built-in functions in Python

```
# useful not commonly available built-in functions
# ------------------------------------------------

import math

value_of_pi = math.pi

angle_in_degree = 90

angle_in_rad = value_of_pi*angle_in_degree/180.0

var2 = math.sin(angle_in_rad)

print("sin(", angle_in_degree,") is ", var2)
```

```
>>> %Run lec3_demo3.py
  sin( 1.5707963267948966 ) is  1.2246467991473532e-16
>>> %Run lec3_demo3.py
  sin( 30 ) is  0.49999999999999994
>>> %Run lec3_demo3.py
  sin( 60 ) is  0.8660254037844386
>>> %Run lec3_demo3.py
  sin( 90 ) is  1.0
>>>
```

Module

- Formally, a module is a component containing Python functions, variables or class
- Each python file (with `*.py`) is a module
- They need to be imported from a module using import
  - Several ways of importing module components

https://docs.python.org/3/tutorial/modules.html

Module import variations

Explicitly need to use ***math.pi*** or ***math.sin***

```
# ------------- Module import variation 1 ----------
import math

# variables initialization
angle_in_degree = 45
angle_in_rad = value_of_pi*angle_in_degree/180.0

# calculation
value_of_pi = math.pi
var2 = math.sin(angle_in_rad)

print("sin(", angle_in_degree,") is ", var2)
```

Directly access ***pi*** and ***sin*** *but nothing else*

```
# ------------- Module import variation 3 ----------
from math import pi
from math import sin

# variables initialization
angle_in_degree = 45
value_of_pi     = pi
angle_in_rad    = value_of_pi*angle_in_degree/180.0
var2            = sin(angle_in_rad)

print("sin(", angle_in_degree,") is ", var2)
```

```
# ------------- Module import variation 2 ----------
from math import *

# variables initialization
angle_in_degree = 45
value_of_pi     = pi
angle_in_rad    = value_of_pi*angle_in_degree/180.0
var2            = sin(angle_in_rad)

print("sin(", angle_in_degree,") is ", var2)
```

Directly access ***pi*** or ***sin***

```
# ------------- Module import variation 4 ----------
from math import pi, sin, cos

# variables initialization
angle_in_degree = 45
value_of_pi     = pi
angle_in_rad    = value_of_pi*angle_in_degree/180.0
var2            = sin(angle_in_rad)

print("sin(", angle_in_degree,") is ", var2)
```

Directly access ***pi*** ***sin*** *and* ***cos*** *(in a single import line) but nothing else*

https://docs.python.org/3/tutorial/modules.html

Topics

- Built-in functions in Python
  - eg, ***input***() receiving input from user
  - No need to define, just call

- Control flow during function call
  - Debugging features of Thonny
  - Step-by-step execution of your program

- Scope of a variable
  - Global scope vs local scope

Control flow during function call

- Should **define** a function before you can **call** the function
- A function can be called from anywhere, even from another function
- Sequence of steps during a function call:
  - Step 1: call a function
  - Step 2: go to the start of that function (inside the function definition)
    - caller is paused
  - Step 3: execute the instructions inside the function
  - Step 4: control goes back to where it's called from

Demo: Control flow during function call

```
1  # Author's name: Md Alimoor Reza
2  # Author's contact: md.reza@drake.edu
3  # Date: (September 7, 2021)
4  # Collaborator:
5  #       self
6
7
8  # this user defined function adds two numbers
9  def add_numbers(num1, num2):
10     sum = num1 + num2
11     return sum
12
13
14 res = add_numbers(1, 3)
15 print("result is ", res)
```

Sequence of steps during a function call:

- Step 1: call a function
- Step 2: transfer to the start of the function (caller is paused)
- Step 3: Execute the instruction inside the function
- Step 4: jump back to where the function was called from

Demo: debug feature of Thonny

Topics

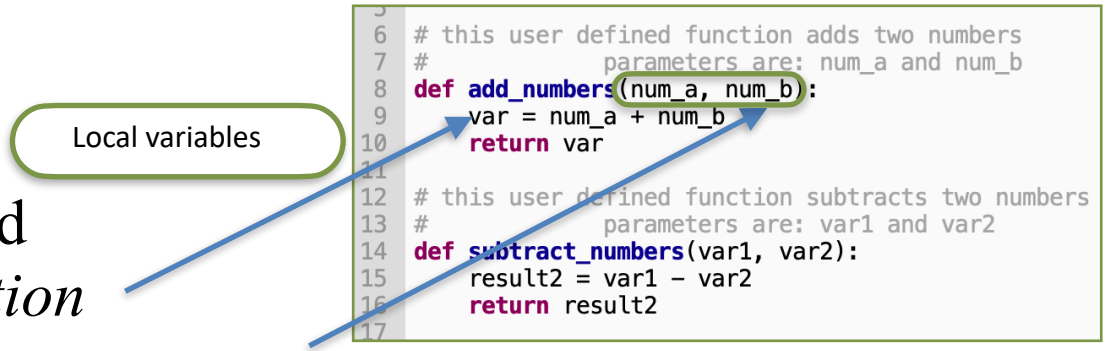
- Built-in functions in Python
  - eg, ***input***() receiving input from user
  - No need to define, just call

- Control flow during function call
  - Debugging features of Thonny
  - Step-by-step execution of your program

- Scope of a variable
  - Global scope vs local scope

Local and global variables

- Local variables:
  - Variables declared
    1. *Inside function*
    2. *As function parameters*
  - Only visible to the defined function



- Global variables:
  - Variables that are defined outside of user defined functions
  - Can be accessed by any function after creation
  - Global variable can be replaced/hidden by local variable if declared with the same name

Scope: local and global variables

- Global variables:
  - Variables that are defined outside of user defined functions
  - Can be accessed by any function after creation
  - Global variable can be replaced/hidden by local variable if declared with the same name

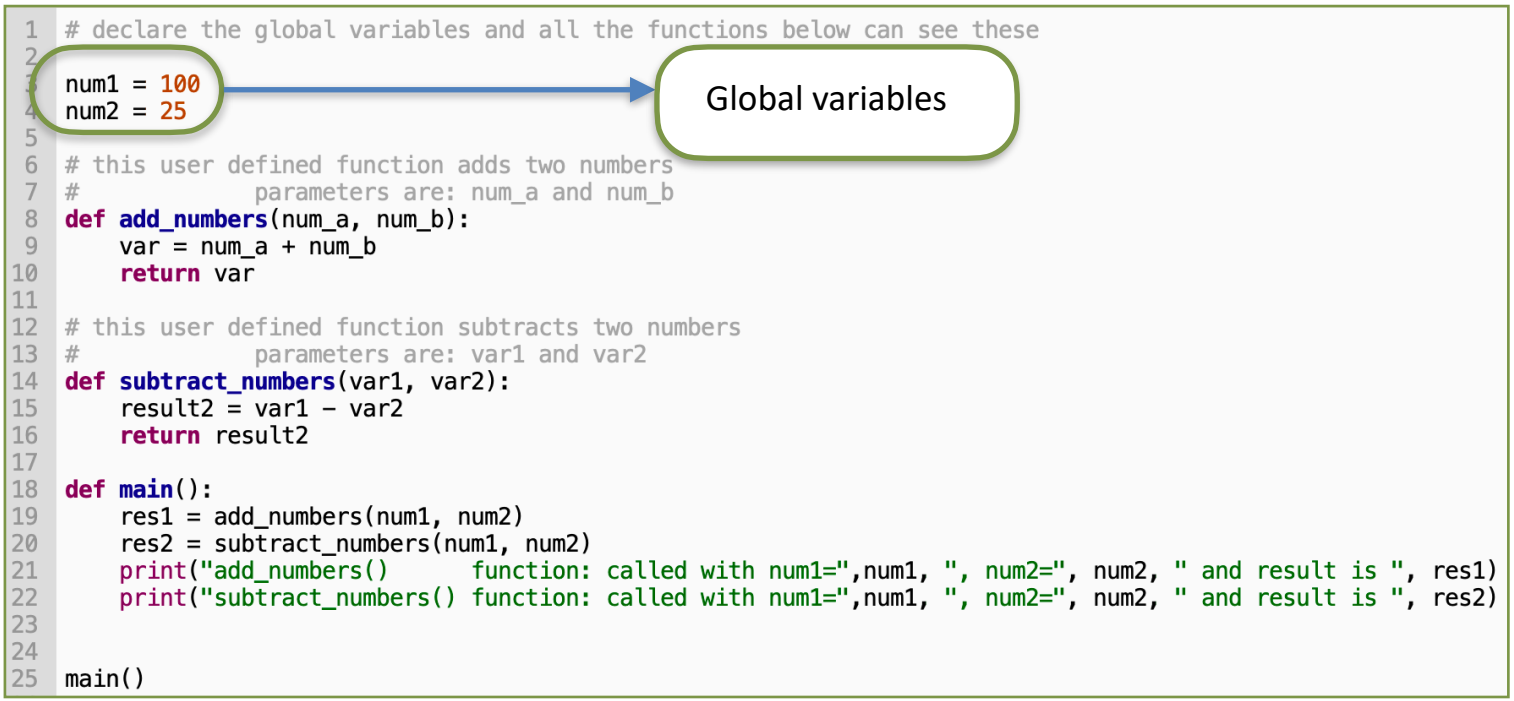
```
num1 = 1


# defining user defined functions
def dummy_function1():
    num1 = 2
    print("Inside function dummy_function1: num1 is local variable ", num1)

print("Before callling dummy_function1() value of num1 = ", num1)

dummy_function1()

print("After callling dummy_function1() value of num1 = ", num1)
```

```
Before callling dummy_function1() value of num1 =  1
Inside function dummy_function1: num1 is local variable  2
After callling dummy_function1() value of num1 =  1
```

Scope: local and global variables

- Global variables:
  - Variables that are defined outside of user defined functions
  - Can be accessed by any function
  - Here values of global variables are copied to the parameters during function call

```
1  # declare the global variables and all the functions below can see these
2
3  num1 = 100
4  num2 = 25
5
6  # this user defined function adds two numbers
7  #             parameters are: num_a and num_b
8  def add_numbers(num_a, num_b):
9      var = num_a + num_b
10     return var
11
12 # this user defined function subtracts two numbers
13 #             parameters are: var1 and var2
14 def subtract_numbers(var1, var2):
15     result2 = var1 - var2
16     return result2
17
18 def main():
19     res1 = add_numbers(num1, num2)
20     res2 = subtract_numbers(num1, num2)
21     print("add_numbers()      function: called with num1=",num1, ", num2=", num2, " and result is ", res1)
22     print("subtract_numbers() function: called with num1=",num1, ", num2=", num2, " and result is ", res2)
23
24
25 main()
```



Demo

```
1  # declare the global variables and all the functions below can see these
2
3  num1 = 100
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7  #            parameters are: num_a and num_b
8  def add_numbers(num_a, num_b):
9      var = num_a + num_b
10     return var
11
12 # this user defined function subtracts two numbers
13 #            parameters are: var1 and var2
14 def subtract_numbers(var1, var2):
15     result2 = var1 - var2
16     return result2
17
18 def main():
19     res1 = add_numbers(num1, num2)
20     res2 = subtract_numbers(num1, num2)
21     print("add_numbers()      function: called with num1=",num1, ", num2=", num2, " and result is ", res1)
22     print("subtract_numbers() function: called with num1=",num1, ", num2=", num2, " and result is ", res2)
23
24
25 main()
```

Global variables

Scope: local and global variables

- Scope resolution: Mechanism of searching for a name, e.g., variable or function

  - **Step 1:** search the referenced name in the local scope. If not found, then go to step 2
  - **Step 2:** search the referenced name in the global scope. If not found, then go to step 3
  - **Step 3:** If searched name is not found in either step 1 or step 2, then search in the built-in scope
  - **Step 4:** If not found in the above steps, then interpreter generates an Error message

Demo

Global variables

- Global variables are defined outside of user defined functions or they can be introduced by the **global** statement

- As you have noticed by now, they can be source of confusion
  - Name clashing
  - Order of their definitions matter

- Use of global variables is not recommended, better to avoid or to minimize (at least) its usage

- If you need to use eg, some constants, then declare them using capital letters

```
VALUE_OF_PI = 3.14
MILES_TO_KILOMETERS = 1.619
```

Summary

- **Takeaway from this lecture:**
  - Calling Python's built-in functions (helper algorithms)
    - Don't need to reinvent the wheel, just use it!
  - Flow of functions can be observed in debug mode of Thonny
  - Global scope vs local scope of variables
    - Minimize the use of global variables

- **To Do:**
  - Finish reading — Chapter 3

- **Announcements:**
  - There will be a paper-based quiz on **Tuesday 09/13/22**
  - Open notes/slides but can't use Thonny
  - Covering topics up to this week
  - Lab 2 will be out soon