Functions
What is a function?

A function is a named sequence of statements that performs a computation.

When we define a function, we write the name and the sequence of statements.

To use the function, we call the function by name.

Functions: properties

• Functions can be defined as a block of re-usuable code to perform specific tasks.

• Reusable code blocks only need to be written once, then they can be used multiple times.

• Functions can be part of the language (built-in functions) or can be defined by the users (user-defined functions).

Functions are called inside the codes with:

1. input parameters (arguments)
2. return values
Functions: example

We have already used some function calls:

\texttt{e.g.: type(3.14)}

The name of the function is:
\texttt{type}

The expression in parentheses is the argument of the function:
\texttt{(3.14)}

The result, for this function, is the type of the argument:
\texttt{<class 'float'>}

Why do we use functions?

- **Modularity**: functions break a program into smaller and modular blocks.
- **Organization**: functions can help manage and organize larger programs.
- **Simplification**: functions avoid repetition and makes code reusable.
- **Reusability**: Once a function is defined, it can be reused several times. We can invoke the same function many times at different location in a program.
- **Abstraction**: Functions provide a high-level view of the program components whose detailed can be filled in later.
Functions: definition

Functions encapsulate a task. Here's how they are defined in Python.

```python
def function_name (formal_parameters):
    '''Optional comment, which is called a docstring,
    describing your function.
    '''
    <function body>
    return <some value or values> # optional
```

Functions: docstring

The docstring (documentation string) is a string placed after the header. It describes the function.

It is a good programming practice to include a docstring in a function for documentation

```python
>>> def check_parity(number):
    '''This function returns the parity of a number'''
    parity = "even" if number % 2 == 0 else "odd"
    return parity
... print (check_parity(6))
... print (check_parity(21))
... even
odd
```
Functions: call

You call the function as follows:

```python
function_name (actual_parameters)
```

This has the effect of executing the function body with the formal parameters replaced by the actual parameters.

Functions: example

What is the execution order and output of the following program?

```python
def print_msg():
    print('I love Python!')

def is_even(num, divisor):
    print(num % divisor == 0)

print_msg()
is_even(10, 2)
is_even(7, 10)
```

Execution order:
1, 4, 7, 1, 2, 8, 4, 5, 9, 4, 5

Output:
I love Python!
True
False
Functions: example

```python
import math

def howdy():
    print("Howdy!")

def welcome(name):
    print(f"Welcome {name}"),
    print ("Let's calculate the volume of a cylinder!")

def cylinder_volume(radius, height):
    area = math.pow(radius, 2) * math.pi
    volume = area * height
    return (volume)

def main():
    name = input("What is your name? ")
    howdy()
    welcome(name)
    radius = float(input("What is the radius of the cylinder? "))
    height = float(input("What is the height of the cylinder? "))
    volume = round(cylinder_volume(radius, height), 2)
    print(f"The volume of the cylinder is {volume}"")
main()
```

Functions: main()

- The `main()` function is a special function that runs automatically when the program is executed.
- It is not required to use `main()` in Python, but it is a good programming practice for the logical structure of the code.
- There is nothing special about the name `main()`.
- We can rename the function `main()` if used as a regular function.
- The name `main()` is consistent with some of the other programming languages.
Activity 5.1

1. Write the name of all the functions in this program

2. What are the inputs and outputs of each function?

3. When do we need to use the return command?

```python
import math

def howdy():
    print("Howdy!")

def welcome(name):
    print(f"Welcome {name}")
    print("Let's calculate the volume of a cylinder!")

def cylinder_volume(radius, height):
    area = math.pow(radius, 2) * math.pi
    volume = area * height
    return (volume)

def main():
    name = input("What is your name? ")
    howdy()
    welcome(name)
    radius = float(input("What is the radius of the cylinder? "))
    height = float(input("What is the height of the cylinder? "))
    volume = round(cylinder_volume(radius, height), 2)
    print(f"The volume of the cylinder is {volume}"

main()
```

Activity 5.1: solution

1. Write the name of all the functions in this program

2. What are the inputs and outputs of each function?

3. When do we need to use the return command?

<table>
<thead>
<tr>
<th>Function name</th>
<th>input(s)</th>
<th>output(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>howdy()</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>welcome()</td>
<td>name</td>
<td>none</td>
</tr>
<tr>
<td>cylinder_volume()</td>
<td>radius, height</td>
<td>volume</td>
</tr>
<tr>
<td>main()</td>
<td>none</td>
<td>none</td>
</tr>
</tbody>
</table>

The return command causes execution to leave the current function. It also allows the function to specify a return value to pass back to the code that called the function.
Activity 5.2

Write a function that returns the absolute value of a number.
Use this function with a function call.

Functions: __main__ special variable

The interpreter sets a special variable __name__ to the value "__main__" when the program is executed by itself in a standalone way.
This helps us know whether the program is ran by itself or whether it is imported by another program.
Using this information, we may or may not execute some of the body of main().

e.g.
1. If we write multiple functions and a main function inside a program $P_1$
2. Then the functions in $P_1$ are imported by another program $P_2$
3. We would not want to execute the main function of $P_1$ in program $P_2$
Example

Write **two** Python programs.
Each program includes a main function.
Import the functions from the first program into the second program and use them.

Functions: **__main__** special variable

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

1. The if statement checks the value of the **__name__** variable.
2. If the value is "**__main__**", then the **main function** is called.
3. Otherwise, it is assumed that the program is imported into another program and we do not want to call main.

Note: conditional execution of the main function is useful when writing code that will be reused by other programs!
Activity 5.3

```python
def gcd(x, y):
    '''This function calculates the GCD of two numbers'''
    while y:
        x, y = y, x % y
    return x

def lcm(x, y):
    '''This function calculates the LCM of two numbers'''
    lcm = (x * y) // gcd(x, y)
    return lcm

def main():
    num = input("Enter two numbers: ").split()
    num = [int(n) for n in num]
    if len(num) == 2:
        print("Highest: {}\nLowest: {}\nGCD: {}\nLCM: {}".format(max(num), min(num), gcd(num[0], num[1]), lcm(num[0], num[1])))
        num.clear()
    if __name__ == "__main__":
        main()
```

List built-in functions, methods and user-defined functions.

Activity 5.3: solution

List built-in functions, methods and user-defined functions.

<table>
<thead>
<tr>
<th>built-in functions</th>
<th>methods</th>
<th>user-defined functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>input()</td>
<td>split()</td>
<td>gcd()</td>
</tr>
<tr>
<td>int()</td>
<td>clear()</td>
<td>lcm()</td>
</tr>
<tr>
<td>len()</td>
<td></td>
<td>main()</td>
</tr>
<tr>
<td>print()</td>
<td></td>
<td></td>
</tr>
<tr>
<td>max()</td>
<td></td>
<td></td>
</tr>
<tr>
<td>min()</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Classify the functions based on input parameters and return values.

```python
def howdy():
    print("Howdy!")

def welcome(name):
    print(f"Welcome {name}")
    print("Let's calculate the volume of a cylinder!")

def cylinder_volume(radius, height):
    area = math.pow(radius, 2) * math.pi
    volume = area * height
    return (volume)
```

<table>
<thead>
<tr>
<th>Function</th>
<th>input</th>
<th>output</th>
</tr>
</thead>
<tbody>
<tr>
<td>howdy()</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>welcome()</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>cylinder_volume()</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>
Guessing game

Modify the The Guessing Game, by changing the part of the code to test if the number is too low or too high into a function.

```python
import random

print('-------------------------------')
print('Welcome to The Guessing Game')
print('-------------------------------

secret_num = random.randint(1, 100)
guess = int(input('Enter a number between 1 and 100: '))

attempts = 1

while guess != secret_num:
    if guess < secret_num:
        print('Too low.')
    else:
        print('Too high.')
    guess = int(input('
Enter a number between 1 and 100: '))
    attempts += 1

print('
Congratulations! You got it in %d guesses.' % (attempts))
```
**Guessing game**

```python
import random

def test_number(guess, secret_num):
    if guess < secret_num:
        return 'Too low.'
    else:
        return 'Too high.'

print('Welcome to The Guessing Game')
print('---------------------------')
secret_num = random.randint(1, 100)
guess = int(input('Enter a number between 1 and 100: '))
attempts = 1
while guess != secret_num:
    print(test_number(guess, secret_num))
    guess = int(input('Enter a number between 1 and 100: '))
    attempts += 1
print('Congratulations! You got it in', attempts, 'guesses.')
```

**Variable scope**

The **scope** of a variable is the **visibility** of the variable. It represents the regions of the program where the variable can be accessed and used.
Variables scope: local vs global

Global variables
Declared outside any function, and they can be accessed (used) on any function in the program.

Local variables
Declared inside a function, and can be used only inside that function.

Functions: local variables vs global variables

```python
v = 15  # global

def f1():
    v = 17  # local
    print ('v(f1): ', v)  # local
    v += 1  # local
    print ('v(f1): ', v)  # local

def f2():
    print ('v(f2): ', v)  # global

f1()
f2()
print ('v: ', v)  # global
```

```bash
$ python variablesGL.py
v(f1): 17
v(f1): 18
v(f2): 15
v: 15
```
Functions: local variables vs global variables

```
1 v = 15          # global
2
3 def f1 ():
4     v = 17      # local
5     print ('v(f1):', v) # local
6     v += 1      # local
7     print ('v(f1):', v) # local
8
9 def f2 ():
10    print ('v(f2):', v) # global
11
12 f1 ()
13 f2 ()
14 print ('v:', v)     # global
```

- When we define a variable inside a function, it is **local** to the function.
- Any changes to this variable has no effect on similar variables outside of the functions.

Functions: local variables vs global variables

- A global variable is declared **outside** of the functions, and can be **accessed** by any functions in the program.
- A variable that is changed or created inside a function is **local** if it is not declared as a **global** variable.
- A variable cannot be **local** and **global** inside a function.
- To tell the interpreter that we want to use a global variable, we explicitly state it in the function using the **global** keyword.
Example

```python
v = 15
def f1 ():
    v = 17
    print ('v(f1): ', v)
def f2 ():
    v += 10
    print ('v(f2): ', v)
f1 ()
f2 ()
print ('v:', v)
```

This program contains an error.
Find it and explain why it is an error.

Activity: solution

```python
v = 15
def f1 ():
    v = 17
    print ('v(f1): ', v)
def f2 ():
global v
    v += 10
    print ('v(f2): ', v)
f1 ()
f2 ()
print ('v:', v)
```

To use the variable v in f2, declare v as global
Functions: local variables vs global variables

```
1     def f ():
2         s = " Only in spring , but London is great as well !"
3             print (s)
4         s = "I am looking for a course in Paris !"
5             print (s)
6         f()
7             print (s)
```

```
>> [evaluate variablesGL4.py]
I am looking for a course in Paris !
  Only in spring , but London is great as well !
I am looking for a course in Paris !
```

Functions: local variables vs global variables

```
1     def foo (x, y):
2         global a
3             a = 42
4         x,y = y,x
5             b = 33
6         b = 17
7             c = 100
8             print (a,b,x,y)
9         a, b, x, y = 1, 15, 3, 4
10        foo (17 , 4)
11     print (a, b, x, y)
```

```
>> [evaluate variablesGL5.py]
42 17 4 17
42 15 3 4
```
Functions: global variables

A function can modify a global Variable.

```python
# I added a comment.
enemy_threat = False; # global variable

def do_something():
    # variables in functions are local by default. Set threat to be a global variable.
    global enemy_threat
    enemy_threat = True

def main():
    do_something()
    # Programmer still expects threat to be False.
    # But do_something() changed it to True!
    if enemy_threat:
        print('Launching nuclear missiles...')
    else:
        print('No threat detected.')
main()
```

Functions: global variables

- Use global variables with caution.
- It is tempting to use lots of global variables because they are easy to work with - especially when many functions are involved.
- Because every function has access to global variables, it can be hard to find which functions read and write these variables.
- To understand how the program works, we have to check every function that modifies the global state.
- Use local variables because other functions cannot affect them directly.
Functions: arguments position

When we call a function with values, the values are assigned to the arguments according to their position.

The arguments can also be assigned via keywords.

```python
# Function Remainder
def remainder(number, divisor):
    return number % divisor

print('Remainder 20 / 7 : %d' % (remainder(20, 7)))

a = 22
b = 5
print('Remainder %d / %d = %d' % (a, b, remainder(a, b)))

number = 36
divisor = 12
print('Remainder %d / %d = %d' % (divisor, number, remainder(divisor, number)))
```

```
Remainder 20 / 7 : 6
Remainder 22 / 5 : 2
Remainder 12 / 36 : 12
```
**Functions: arguments keyword**

```python
# Function Remainder
def remainder(number, divisor):
    return number % divisor

print('Remainder 20 / 7 : %d%(remainder(20, 7)))
print('Remainder 7 / 20 : %d%(remainder(7, 20)))
print('Remainder 20 / 7 : %d%(remainder(20, divisor = 7)))
print('Remainder 20 / 7 : %d%(remainder(number = 20, divisor = 7)))
print('Remainder 20 / 7 : %d%(remainder(divisor = 7, number = 20)))
```

```python
[evaluate teste.py]
Remainder 20 / 7 : 6
Remainder 7 / 20 : 7
Remainder 20 / 7 : 6
Remainder 20 / 7 : 6
Remainder 20 / 7 : 6
```

---

**68 Built-in Functions**

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<td>super()</td>
<td></td>
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<td>input()</td>
<td>open()</td>
<td>tuple()</td>
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