Introduction to Computer Programming

Week 4.1: Functions

Functions

Functions are the building blocks of Python programs

- They can be thought of as mini-programs that carry out specific tasks (e.g. square a number)

A function is a collection of operations that have been given a name

- These operations can involve variable assignment, mathematical operations, loops, if-else statements, etc

Python comes with a number of built-in functions

- `max(L)` computes the maximum entry in a list of numbers called L

We can also write our own functions in Python

- We could write a function `is_prime(n)` that determines whether an integer n is prime

What are the benefits of writing our own functions?

- It reduces the need to copy and paste code that does the same operation, making code more reusable
- It makes programs easy to maintain, more readable, and easier to understand

An analogy with mathematical functions

In maths, we often work with functions of the form $y = f(x)$, where

- x is an input (e.g. a number)
- f is the function which carries out operations on x, such as x^2 or $\sin(x)$
- y is the output, that is, the result of carrying out the operations on x

Functions in Python work in the same way, but are much more powerful:

- Python functions take inputs which can be ints, floats, lists, dicts, etc!
- They can carry out multiple operations that aren't necessarily mathematical
- And they may produce no outputs, one output, or many outputs

Some programming terminology

Inputs to functions are called **arguments**

When we run or execute a function, we say that we are **calling** the function

Defining our own functions

Every function definition is of the form

```
def name_of_function(arg1, arg2, ...):
    # indented block of code
```

The key ingredients are:

- `def` is a keyword that tells Python we are defining a function
- *name_of_function* is the name of the function
- *arg1*, *arg2*, ... are comma-separated arguments (inputs) that we provide to the function
- Round brackets that surround the arguments, followed by a colon
- A block of indented code

Example: Let's write a function that doubles the value of a number x and prints the result:

In [13]:
```
def double(x):
    print(2*x)
```

Once a function is defined, it can be used. For example:

In [14]:
```
double(4)
```

```
8
```

In [15]:
```
var = 6
double(var)
```

```
12
```

Example: Write a function without any arguments that prints 'Hello'

In [1]:
```
def print_hello():
    print('Hello')

print_hello()
```

```
Hello
```

Example: Write a function that prints all of the entries in a list that is provided as an argument

In [2]:
```
def print_list(L):
    for l in L:
        print(l)

L = ['Python', 3, 'is', 'super', 'fun']
print_list(L)
```

```
Python
3
is
super
fun
```

Producing output using `return`

In the previous example, we defined a function to double the number x. The `return` keyword can be used to save the output of this function to a new variable:

In [4]:
```
def double(x):
    return 2 * x
```

When the function `double(x)` is called, it **returns** the value of $2x$, which can be assigned to a variable. For example:

In [5]:
```
y = double(3)
print(y)
print(2*y)
```

```
6
12
```

Example: Write a function that determines whether an integer is even. If so, the function returns the boolean True. Otherwise, the function returns the boolean False.

In [3]:
```
def is_even(n):
    if n % 2 == 0:
        return True
    else:
        return False

n = 4
print(is_even(n))

m = 55
print(is_even(m))
```

```
True
False
```

Returning multiple outputs

Python makes it easy to return multiple outputs using tuples

Example: The function below returns the sum and product of two numbers. It has two arguments, x and y, that are separated by commas.

In [20]:
```
def sum_prod(x, y):
    return (x + y, x * y)
```

There are two ways we can run this function and save the output:

In [22]:
```
def sum_prod(x, y):
    return (x + y, x * y)

# save the output as a tuple
output = sum_prod(3, 6)
print(output)

# save the output as two numbers
(s, p) = sum_prod(3, 6)
print(s)
print(p)
```

```
(9, 18)
9
18
```

More about the `return` keyword

The `return` keyword is optional, but it can play two important roles in functions:

1. It is used to define the output of a function, if there is any
2. It is used to exit a function prematurely (similar to `break` in loops)

The second point means the `return` statement is useful in controlling the flow of functions that involve `if` statements

Consider the following function:

In [8]:
```
def my_function(x):
    print('x equals', x)
    return
    print('2x equals', 2 * x)
```

When the function is called, it proceeds through each statement until the `return` keyword is encountered, at which point the function terminates, and any values that follow `return` are returned as outputs

In [9]:
```
my_function(2)
```

```
x equals 2
```

Since there is nothing that follows `return` in this example, the function does not output anything

Good programming practice - docstrings

Python programs often involve many user-defined functions, and it can be difficult to remember what they do and how they should be used.

A **docstring** is text in triple quotation marks placed below the name of the function that explains what it does.

In [10]:
```
def square(x):
    """
    Computes the square of a real number x and returns its value
    """
    return x * x
```

Python's `help` function can be used to print the docstring:

In [11]:
```
help(square)
```

```
Help on function square in module __main__:

square(x)
    Computes the square of a real number x and returns its value
```

Example: Define and document a function that computes the average of two numbers

In [1]:
```
def average(a, b):
    """
    Computes the average value of two numbers, a and b.
    """

    # compute the mean value
    mean = (a + b) / 2

    # return the value
    return mean
```

In [3]:
```
help(average)
c = average(4, 7)
print(c)
```

```
Help on function average in module __main__:

average(a, b)
    Computes the average value of two numbers, a and b.

5.5
```

Summary

- A function is a group of code that has been given a name
- They can take input and produce output
- Functions are defined using the `def` keyword
- Output is producing using the `return` keyword
- Docstrings are helpful for explaining what a function does and how to use it