# Laboratory Exercise 04

## Topics

1. Design and implementation of functions
    a. Passing parameters
    b. Use of return statement
2. Gradual refinement (*Stepwise refinement)* to break down complex operations into simpler ones
    a. Design of multiple functions to be used together
    b. visibility (*scope)* of a variable

## Discussion

A. What does it mean that the user of a function can consider it as a "black box”?
B. What is the difference between returning a value and generating an output value for a function?
C. How can you make a function reusable?
D. What is the *scope* of visibility of a variable?

## Exercises

### Part 1 – Single functions

**4.1.1 Speech Count.** Write the function:

```
def count_vowels(string)
```

Returns the number of vowels in the `string`. Vowels are the letters `a`, `e`, `i`, `o`, and `u`; as well as their respective capitalized versions. [P5.6]

**4.1.2 Word Count.** Write the function:

```
def count_words(string)
```

Returns the number of words in the `string`. Words are sequences of characters separated by spaces (assume that between two consecutive words, there is exactly one space). For example, `count_words("Mary had a little lamb")` returns `5`.

How could the exercise be extended so that strings, where there are multiple spaces between words, are correctly treated? [P5.7]

**4.1.3 Geometric solids.** Write functions:

```
def sphere_volume(r)
def sphere_surface(r)
def cylinder_volume(r, h)
def cylinder_surface(r, h)
def cone_volume(r, h)
def cone_surface(r, h)
```

To calculate the volume and surface area of a sphere of radius `r`, a cylinder with a circular base of radius `r` and height `h` and a cone with a circular base with radius `r` and height `h`. Then write a program that asks the user to enter the values `r` and `h`, then the program calls the six functions and display the output results. [P5.9]

**4.1.4 Bank Balance.** Write a function that calculates the balance of a bank account by crediting interest annually. The function receives as parameters: the number of years, the initial balance, and the annual interest rate. [P5.22]

## Part 2 – Algorithms that make use of functions

**4.2.1 NGOs.** A non-governmental organization needs a program to calculate the share of financial benefit to be allocated to each family in need of assistance. The formula is as follows:

I. If the family's annual income is between `$30000` and `$40000` and the family has at least `3` children, the subsidy is `$1000` for each child;
II. If the family's annual income is between `$20000` and `$30000` and the family has at least `2` children, the subsidy is `$1500` for each child;
III. If the family's annual income is less than `$20,000,` the subsidy is `$2,000` for each child.

Write a function to perform these calculations. Then write a program that, in a cycle, asks the user to provide the annual income and the number of children of each family requesting the subsidy, displaying the corresponding value returned by the function. Use `-1` as the sentinel value to finish entering data. [P5.28]

**4.2.2 Roman numerals.** Write a program that converts a Roman numeral, such as `MCMLXXVIII,` into its decimal representation.

*Tip:* First, write a function that returns the numeric value of each individual letter, then use the following algorithm:

`total` *= 0*
`s` *= string corresponding to the Roman numeral*
*Until* `s` *is empty*

*If* `s` *has length 1, or the value of its first character is greater than or equal to the value of its second character*

*Add the value of the first character of* `s` *to the total*

*Remove the first character from* `s`

*Otherwise* `difference` *= (value of the second character of* `s`*) – (value of the first character of* `s`*)*

*Add the difference value to the* `total`

*Remove the first two characters from* `s`

[P5.27]

**4.2.3 Aerodynamic drag.** The drag force on a car is given by:

$$F_D = 1/2 - \rho v^2 A C_D$$

Where $\rho$ is the air density ($1{,}23\ kg/m^3$), $v$ is the velocity in $m/s$, $A$ is the projected area of the car ($2{,}5\ m^2$) and $C_D$ is the drag coefficient ($0{,}2$). The amount of power in watts needed to overcome the resistance force is $P = F_D v$, and the equivalent power in horsepower is $Hp = P/745.7$. Write a program that receives the car's speed and calculates the power in watts and horsepower needed to overcome the resulting resistance force. [P5.36]

**4.2.4 Electrical wire.** The electric wire is a cylindrical conductor covered with an insulating material. The resistance of a wire is given by the formula:

$$R = \frac{\rho L}{A} = \frac{4\rho L}{\pi d^2}$$

Where $\rho$ is the resistivity of the conductor $L$ and $A$, and $d$ are the length, cross-sectional area, and wire diameter, respectively. The resistivity of copper is ($1.678 \times 10^{-8}\ \Omega m$). The diameter $d$ of the wire, is commonly specified by the American Wire Gauge (AWG), which is an integer value. The diameter of an AWG-$n$ wire is given by the formula:

$$d = 0.127 \times 92^{\frac{36-n}{39}}\ mm$$

Write a function

```
def diameter(wire_gauge)
```

that accepts the wire gauge and returns the corresponding diameter. Write another function

```
def copper_wire_resistance(length, wire_gauge)
```

that accepts the length and caliber of a piece of copper wire and returns its resistance.

The resistivity of aluminum is $2{,}82 \times 10^{-8}\ \Omega m$. Write a third function

```
def aluminum_wire_resistance(length, wire_gauge)
```

that accepts the length and caliber of a piece of aluminum wire and returns its resistance. Then write a program to test these functions. [P5.35]