**MECA0027-1**
Structural and multidisciplinary optimization
Academic year 2022-2023

# Computer work 1: Unconstrained optimization

## 1 Objectives

The goal of this first computer work is to familiarize the student with unconstrained optimization and the practical implementation of different methods seen in theoretical lectures. To do so, it is asked to minimize two different functions $f_1$ and $f_2$, defined as:

$$f_1 = 2x^2 - 3xy + 2y^2 - 2x + 10y - 1 \tag{1}$$
$$f_2 = x^4 + x^3 - 2x^2 - 2x + y^2 \tag{2}$$

using the methods listed hereafter:

1. Steepest descend method;
2. Conjugate gradients method with Fletcher-Reeves update rule;
3. BFGS Quasi-Newton method.

## 2 Analysis

Following the developments of the different methods, a thorough and critical analysis is expected and must be organized in two parts. First, one must compare the methods on each of the two functions based on:

1. at least two different starting points (except (0,0)) and justify their choosing;
2. stopping criteria;
3. number of iterations to convergence, evolution of the objective function, number of function evaluations.

Second, it is also asked to discuss the differences in results observed between the two functions and conclude with the strengths and weakness of the different methods.

## 3 Organization and grading

This work is to be performed in group of 2 students, which have to be constituted for October 11 to the latest. Note that groups will remain identical for the second computer work. Each group must submit its Matlab (or Octave) files and a short report (max 10 pages) of its analysis within a .zip or .rar archive file named as "student1_student2".

The deadline for submission is October 30, 2022. The documents should be sent by email to Nayan.Levaux@uliege.be.

The final grade will take into account both the quality of the report (content, design, figures, text, tables etc.), the results (implementation of the methods) and analysis.

# 4 In practice

You should start by editing the file `getObjFVal.m` to define the functions $f1$ and $f2$. Then, define Matlab files for the gradient and hessian matrix of those functions in the same fashion. When it is done, edit the file `HW1.m` (while keeping the notations of the code) and add your implementation of the methods in the zone ADD YOUR CODE and comment it.

Don't forget to use the provided file `plotOptimizationPath.m` to visualize your optimization path as it can be useful for debugging.

Notice that the following convention is used for the variables:

- $x$ contains the pair of coordinates during the optimization

$$x = \begin{bmatrix} x_0 & x_1 & ... & x_n \\ y_0 & y_1 & ... & y_n \end{bmatrix}; \tag{3}$$

- "functionID" values are either 1 or 2 depending on which function you want to work with.