UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF APPLIED COMPUTER SCIENCE
AND MODELLING

**FUNDAMENTALS OF OPTIMIZATION**

# Multi-variable optimization using non-deterministic mehods

## 1. Aim of the exercise.

The aim of the exercise is using non-deterministic optimization methods to find the minimum of the given objective function.

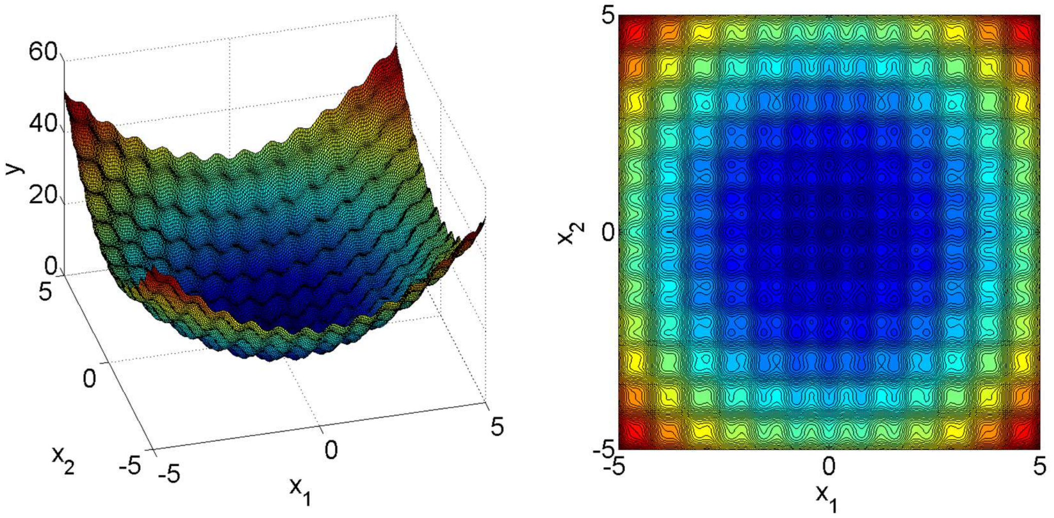
## 2. Test function.

The test function is given by following equation:

$$f(x_1, x_2) = x_1^2 + x_2^2 - cos(2{,}5\pi x_1) - cos(2{,}5\pi x_2) + 2$$

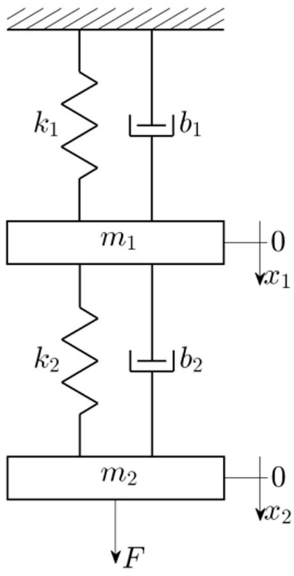
where: $x_1 \in [-5, 5], x_2 \in [-5, 5]$.

The test function is shown in the figure below.

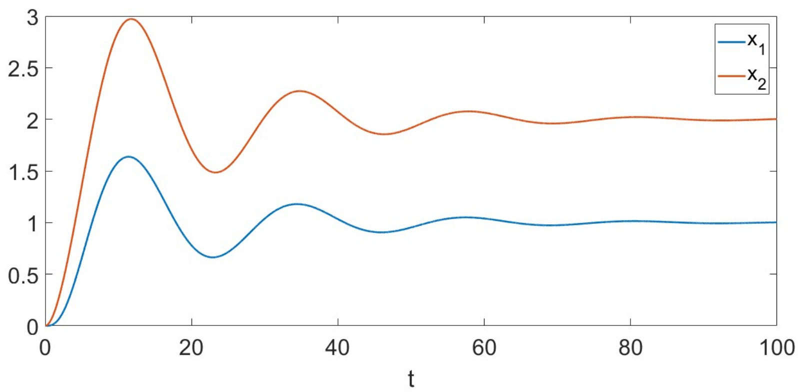



## 3. Inverse analysis.

Two weights of mass $m_1 = 5kg$ and $m_2 = 5kg$ are suspended on springs with stiffness coefficients of $k_1 = 1\,{}^{N}/_{m}$ and $k_2 = 1\,{}^{N}/_{m}$ respectively (see figure below).




The friction coefficients $b_1$ and $b_2$ are responsible for the resistance to motion, and the variables $x_1$ and $x_2$ represent the position of the weights. The experiment was carried out, consisting in applying the force $F = 1N$ to the lower weight and observing the position of the weights. The position of the weights are presented in the figure below.




The equations for the movement of the weights are as follows:

$$\begin{cases} m_1\ddot{x}_1 + b_1\dot{x}_1 + b_2(\dot{x}_1 - \dot{x}_2) + k_1x_1 + k_2(x_1 - x_2) = 0 \\ m_2\ddot{x}_2 - b_2(\dot{x}_1 - \dot{x}_2) - k_2(x_1 - x_2) = F \end{cases}$$

The position of the weights (vectors x1 and x2) and the time vector (t) are saved in the **data.mat** file. The experiment lasted 100s, and the positions were recorded every 0.1s.

The aim of optimization is finding the values of friction coefficients $b_1 \in [0.1; 3]\ ^{Ns}/_{m}$ and $b_2 \in [0.1; 3]\ ^{Ns}/_{m}$, for which the experiment was carried out. The simulation of the weight movement should be performed for the time $t_0 = 0s$, $dt = 0.1s$, $t_{end} = 100s$.

## 4. Optimization methods.

To perform optimization use **ga** function.

## 5. Realization of the exercise.

During the exercise four m-files should be written:

- **start.m** – a script which runs all computations. It should:
    - display the names of the Authors of the code,
    - display the optimum found for the test function ($\mathbf{x}$, $y$ and the number of objective function calls),
    - display the optimum found for the inverse analysis ($b_1$, $b_2$, fitness function value and the number of objective function calls),
    - plot figure showing the difference between the experiment and the simulation performed using optimum values of $b_1$, $b_2$.
- **ff_test.m** – a function which calculates and returns the test function value: **y=ff_test(x);**
- **ff_inverse.m** – a function which calculates and returns the fitness function for the inverse analysis problem: **y=ff_inverse(x,t,x1,x2);** where $x = \begin{bmatrix} b_1 \\ b_2 \end{bmatrix}$, t, x1, and x2 are experiment values (from **data.mat** file)
- **simulation.m** – a function which performs weights movement simulation and returns the vectors of weights positions and time: **[t,x1,x2]=simulation(b1,b2)**, where t, x1 and x2 are simulation values (obtained for given b1 and b2 values).

## 6. Report.

As the report, four m-files should be sent via UPeL platform (by one Author only).