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

FUNDAMENTALS OF OPTIMIZATION

Optimization of one-variable problems using non-gradient mehods

1. Aim of the exercise.

The aim of the exercise is using non-gradient optimization methods to find minimum of the given test function and to solve simple optimization problem.

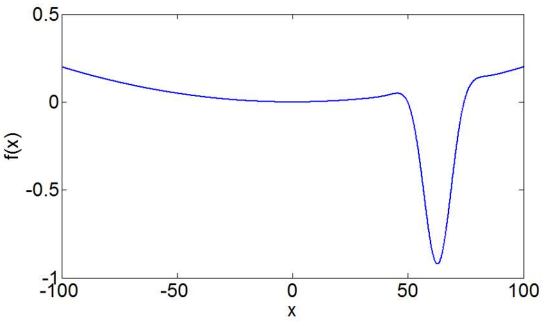
2. Test function.

The test function is given by following equation:

$$f(x) = -cos(0{,}1x) \cdot e^{-(0{,}1x-2\pi)^2} + 0{,}002 \cdot (0{,}1x)^2$$

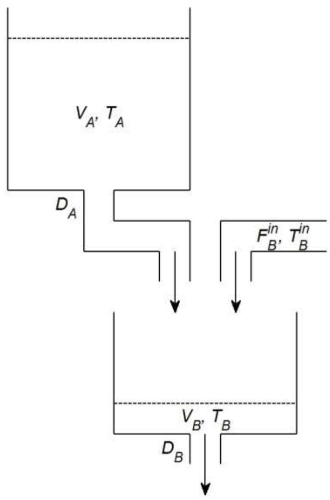
where: $x \in [-100, 100]$.

The test function is shown in the figure below.



3. Two water tanks problem.

There are two tanks A (upper) and B (lower) filled with water as showed in the figure below.



The area of tank A bottom is equal to $P_A = 1m^2$ and it consists the $V_A^0 = 5m^3$ of water at the temperature $T_A^0 = 90°\text{C}$. The area of tank B bottom is equal $P_B = 1m^2$ and it consists $V_B^0 = 1m^3$ of water at the temperature $T_B^0 = 10°\text{C}$. The water from tank A is poured into tank B through the valve of the surface area equal to D_A. Moreover, the $F_B^{in} = 10\, {}^{l}/_{s}$ water at temperature $T_B^{in} = 10°\text{C}$ is poured into tank B. The water from tank B splits out through the valve of the surface area equal to $D_B = 36.5665cm^2$. The change of the volume of water in tank caused by splitting out is given by the following formula:

$$\frac{dV}{dt} = -a \cdot b \cdot D \cdot \sqrt{2g\frac{V}{P}},$$

where: D – surface area of valve opening, $a = 0.98$ – coefficient describing the fluid viscosity, $b = 0.63$ – coefficient depending on the valve shape, $g = 9.81\, {}^{m}/_{s^2}$ – gravity acceleration.

The change of the temperature of water in tank is given by the following formula:

$$\frac{dT}{dt} = \frac{V^{in}}{V} \cdot \left(T^{in} - T\right),$$

where: V^{in}, T^{in} – volume and temperature of water input stream, V, T – volume and temperature of water in the tank.

The goal of optimization is finding the surface area of valve opening $D_A \in [1, 100]cm^2$, for which the maximal temperature of water in tank B is equal to $50°\text{C}$. The simulation of the system of tanks should be performed for time $t \in [0,1000]s$ with a time step $dt = 1s$.

4. Optimization methods.

To perform optimization use **fminbnd** 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 (x, y and the number of objective function calls),
  - plot the figure showing the test function and found optimum,
  - display the optimum found for the two tanks problem (DA, y and the number of objective function calls),
  - plot three figures showing the volume of water in tank A, the volume of water in tank B and the temperature of water in the tank B as the function of time.
- **ff_test.m** – a function which calculates and returns the test function value at given point: **y=ff_test(x)**
- **ff_tanks.m** – a function which calculates and returns the objective function value in the two tanks problem: **y=ff_tanks(DA)**
- **sim_tanks.m** – a function which returns the vectors containing the volume of water in tank A, the volume of water in tank B and the temperature of water in the tank B:

[t,VA,VB,TB]=sim_tanks(DA). When writing this function, take into account that the water volume in the tank cannot be negative. If you encounter a problem (with meeting integration tolerances) using a **ode45** function, try **ode23** function.

To validate if the function is written correctly perform the simulation for $D_A = 50cm^2$. The maximum temperature in the B tank should be about 59.64℃.

6. **Report.**

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