KEB-45251
Numerical Techniques for Process Modeling
Exercise 4 - Optimization
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Problem 1

We will start by playing with a practice function

$$f = x \sin(x) + 0.2x^2 - 3 \tag{1}$$

in range $x \in [0, 10]$. **Start by plotting the function. Then find**

(a) **root with root**

(b) **root with root_scalar using bracket**

(c) **minimum with minimize_scalar**

(d) **maximum with minimize_scalar**

(e) **root using using minimize_scalar**

(f) **minimum with constraint (use penalty)** $h \geq 0$,

$$h = f(x+6)^{1/2} - x \tag{2}$$

(extra) **do the same using pyswarm (`pythonhosted.org/pyswarm/`)**

The function is intentionally chosen to easily give false results. Remember to check the results! Note that in real life, you may not be able to do this.

We do not have a template for this exercise. See previous exercises, lecture slides, and Scipy documentation (https://docs.scipy.org/doc/scipy/reference/optimize.html) for hints.

Problem 2

In Fig. 1 we have schematics for an impinging jet and experimental data for local heat transfer. The data was measured by Alimohamadi et. al., the full paper is attached.

As usual, the measurement data comes in a discrete format. **Use interpolation between data points and plot the results**.

From experience, it is known that the heat transfer starts to decrease monotonically after some distance from the stagnation point. **Fit an exponentially decreasing function to the data and plot results**.

See lecture slides for hints and use template.

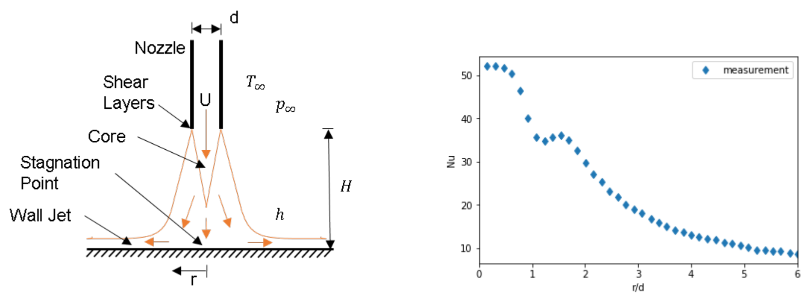

Figure 1: Impinging jet. Measurement data by Alimohammadi.

Problem 3 - Extra

Similarly to problem 1 in exercise 1, we have cold water entering a hot pipe. The initial water temperature is $T_{in} = 30\,°\mathrm{C}$ and we want the outlet temperature to be $T_{out} = 80\,°\mathrm{C}$. The pipe wall temperature is $T_w = 100\,°\mathrm{C}$. Water mass flow rate is $\dot{m} = 0.5\,\mathrm{kg/s}$. Maximum allowed pressure loss in the pipe is $\Delta p_{max} = 1\,\mathrm{kPa}$. **Choose the pipe inner diameter d which minimizes pipe mass.** Pipe wall thickness is 2 mm and the pipe is made from copper.

A template *is* available. **First implement the function *pipe* which solves the problem with one diameter and test it**. **Then solve the optimization problem using penalty method**.

You may also verify your solution using brute force and plotting.