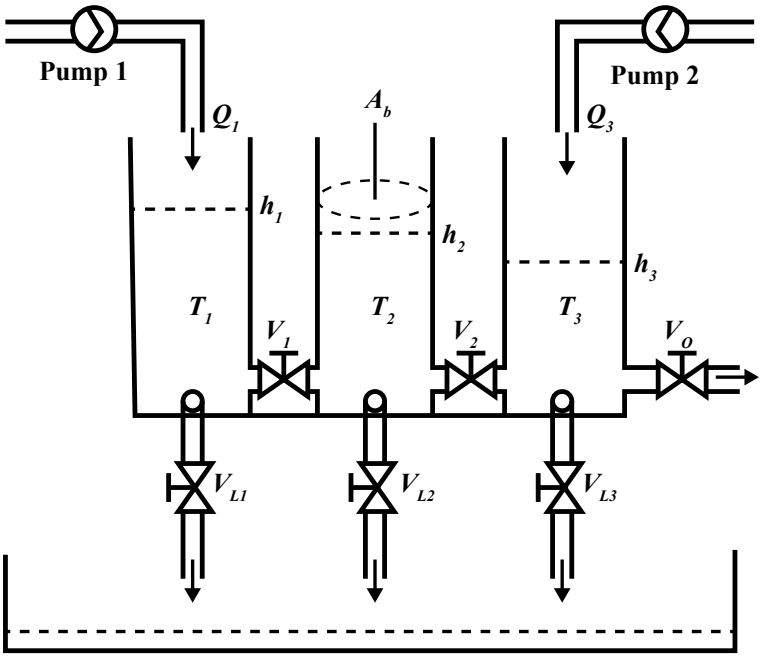
CHEM-E7190/2023: Exercise I - Modelling + simulation (Euler)

Task 1.

Consider the three tank system. In the system, Q_1 and Q_3 are inflow rates and h_1, h_2 and h_3 are liquid levels. The process consists of three cylindrical tanks (T_i, $i = 1, 2, 3$) connected by two fixed valves (V_i, $i = 1, 2$), with an outflow valve V_0 for the last tank

1. h_1, h_2 and h_3 are the outputs and Q_1 and Q_3 are the inputs.



Additional assumptions:

1. Density of the liquid ρ is is constant.

Familiarise with programs `ThreeTankSystemNonLinmain_template.m` and `ThreeTankSystemNonLin_template.m`. Experiment on how to simulate the system from different initial conditions $x(t=0) = \begin{bmatrix} x_1(0) \\ x_2(0) \\ x_3(0) \end{bmatrix}$ and varying inputs $u(t) = \begin{bmatrix} u_1(t) \\ u_2(t) \end{bmatrix}$. Then implement your mode of the three tank system with programs named, for example, `ThreeTankSystemNonLinmain.m` and `ThreeTankSystemNonLin.m`.

Table 1: Three tank system parameters

Cross section area of the tank (A_b)	0.0154m^2
Cross section area of the pipes (A_c)	$5 \cdot 10^{-5}\text{m}^2$
Valve V_1 opening position with friction (α_{12})	$\alpha_{12} = 0.476$
Valve V_2 opening position with friction (α_{23})	$\alpha_{23} = 0.479$
Valve V_O opening position with friction (α_{3O})	$\alpha_{3O} = 0.771$
Maximum flow rate constraint (Q_{max})	$1.2 \cdot 10^{-4}\text{m}^3/\text{s}$
Maximum level (h_{max})	0.63m

Questions to be answered:

Q1) Study the process diagram, then write the total mass balance equations for the liquid levels. Please note that the water level in tank 1 can be higher than tank 2, or vice versa, where the water level in tank 2 is higher than tank 1. The same applies to tank 2 and tank 3.

Q2) Compare the non-linear model with the data collected from the laboratory. Use the input and output values from the data.

Q3) Compare the non-linear model with different input signals and analyse the results.

- Utilize, for example, a step as an input signal.

You can use program `plotThreeTankSystem_template.m.m` to plot your results. You can also modify it to suit your needs.