# CHEM-E7190/2021: Exercise II - Linearization + simulation (Euler)

Task 1. Consider the stirred-tank heating system. The liquid inlet stream consists of a single component with a mass flow rate w_i and an inlet temperature T_i. The tank contents are agitated and heated using an electrical heater that provides a heating rate, Q. A dynamic model will be developed based on the following assumptions:
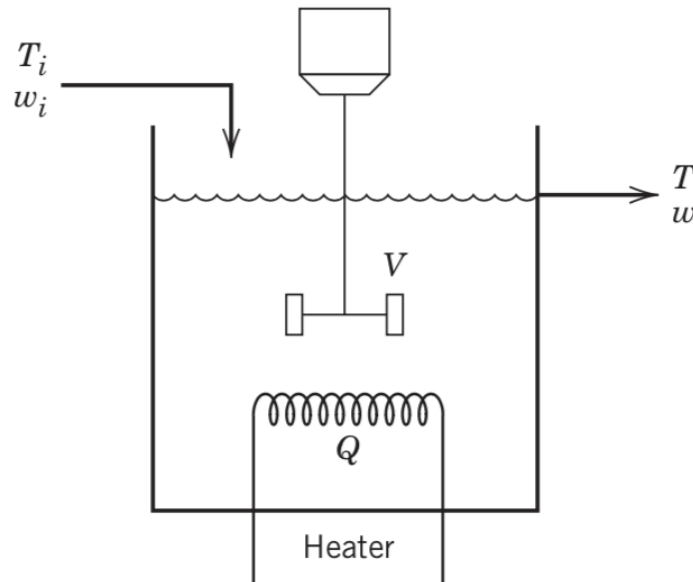
1. Perfect mixing; thus, the exit temperature T is also the temperature of the tank contents.

2. The density ρ and heat capacity C of the liquid are assumed to be constant. Thus, their temperature dependence is neglected.

3. Heat losses are negligible.

4. The flow rate exiting the tank is through an orifice, and the overall rate is dictated by hydrostatic forces.

The mass balance for the tank is:
$$\frac{\mathrm{d}V(t)}{\mathrm{d}t} = \frac{1}{\rho}(w_i(t) - C_v\sqrt{\frac{V(t)}{A}})$$

Energy balance for tank:
$$\frac{\mathrm{d}T(t)}{\mathrm{d}t} = \frac{w_i(t)}{\rho V(t)}(T_i(t) - T(t)) + \frac{Q(t)}{\rho V(t)C_c}$$

$V(t)$ and $T(t)$ are the state variables, $w_i(t)$, $T_i(t)$ and $Q(t)$ are the inputs and ρ, C_v, A and C_c are the model parameters.

0. Verify that the given model equations are correct;

1. Write a script (with model function) to simulate the reactor for different initial conditions and inputs;

2. Choose $\rho = 1$, $C_v = 1$, $A = 1$ and $C_c = 1$ for the model parameters, reasonable values for the initial conditions $(V(0), T(0))$ and the inputs $(w_i(t), T_i(t), Q(t))$, for $0 \leq t \leq t_f$ and test your implementation. To verify/demonstrate the correctness of your implementation, display the evolution of all model variables.

3. For the chosen model parameters, define a set of operating conditions $(w_i^{SS}, T_i^{SS}, Q^{SS})$ of your choice to run the reactor and find the corresponding steady-states (V^{SS}, T^{SS}) by simulating the process for a sufficiently long tine.

4. Linearise the model around that steady-state and implement the linearised model and compare its evolution with the nonlinear one under the same conditions defined in (2.). Do not forget to verify the correctness of the linearised model above and plot the temporal evolution of all the involved process variables, to show the correctness of your code.