The goal of the following exercises is to be able to solve problems using the Levenspiel diagram technique.

Problem 1

The hydrolysis of sucrose (S) into glucose (G) and fructose (F) is carried out on a large scale for the production of inverted sugar. The reaction can be described as follows:

$$S \rightarrow G + F$$

Inverted sugars find widespread use in the food industry. The hydrolysis is catalyzed by the enzyme Invertase, which is subject to substrate inhibition (here, inhibition by sucrose). The kinetics can be well described by a modified Michaelis-Menten model to account for substrate inhibition.

The rate of the hydrolysis reaction r (mol/L·min) is given by the following relationship:

$$r = \frac{V_m \cdot C_S}{K_M + C_S + \frac{C_S^2}{K_{iS}}}$$

V_m, K_m et K_{iS} are constants given below:

$V_m = 2.97 \cdot 10^{-2}$ (mol/L·min)

$K_m = 0.342$ (mol/L)

$K_{iS} = 0.379$ (mol/L)

The initial concentration of saccharose C_{SO} is 2 mol/L.

- Using the Levenspiel diagram technique, what is the residence time to achieve 80% conversion in a CSTR reactor?
- Using the Levenspiel diagram technique, what is the residence time to achieve 80% conversion in a PFR reactor?
- Using the Levenspiel diagram technique, what is the residence time to achieve 99% conversion in a CSTR reactor?
- Using the Levenspiel diagram technique, what is the residence time to achieve 99% conversion in a PFR reactor?
- Using the Levenspiel diagram technique, what is the minimal residence time to achieve 99% conversion in a combination of two CSTR reactors?
- Using the Levenspiel diagram technique, what is the minimal residence time to achieve 99% conversion in a combination of PFR and CSTR reactors?
- Using the Levenspiel diagram technique, what is the minimal residence time to achieve 99% conversion in a single PFR reactor with an optimal recycle stream?

Problem 2

In the presence of a specific enzyme E, which acts as a homogeneous catalyst, a hazardous organic compound A present in an industrial waste is degraded into harmless chemicals. At a given enzyme concentration C_E, the following preliminary experiments were carried out in the laboratory in a CSTR reactor:

C_{A0}(mmol/m^3)	2	5	6	6	11	14	16	24
C_A(mmol/m^3)	0.5	3	1	2	6	10	8	4
τ (min)	30	1	50	8	4	20	20	4

Using the above laboratory experimental data, try to design a reactor capable of treating 0.1 m^3/min of this wastewater with an initial concentration of A of 10 mmol/m^3. The desired conversion rate is 90% and the enzyme concentration is constant at CE. What will be the optimum reactor volume for:

- A PFR reactor
- A CSTR reactor
- Two CSTR reactors of equal size
- Two CSTR reactor with a minimal total volume
- A series of PFR and CSTR reactors with a minimal total volume
- One PFR reactor with an optimal recycle stream