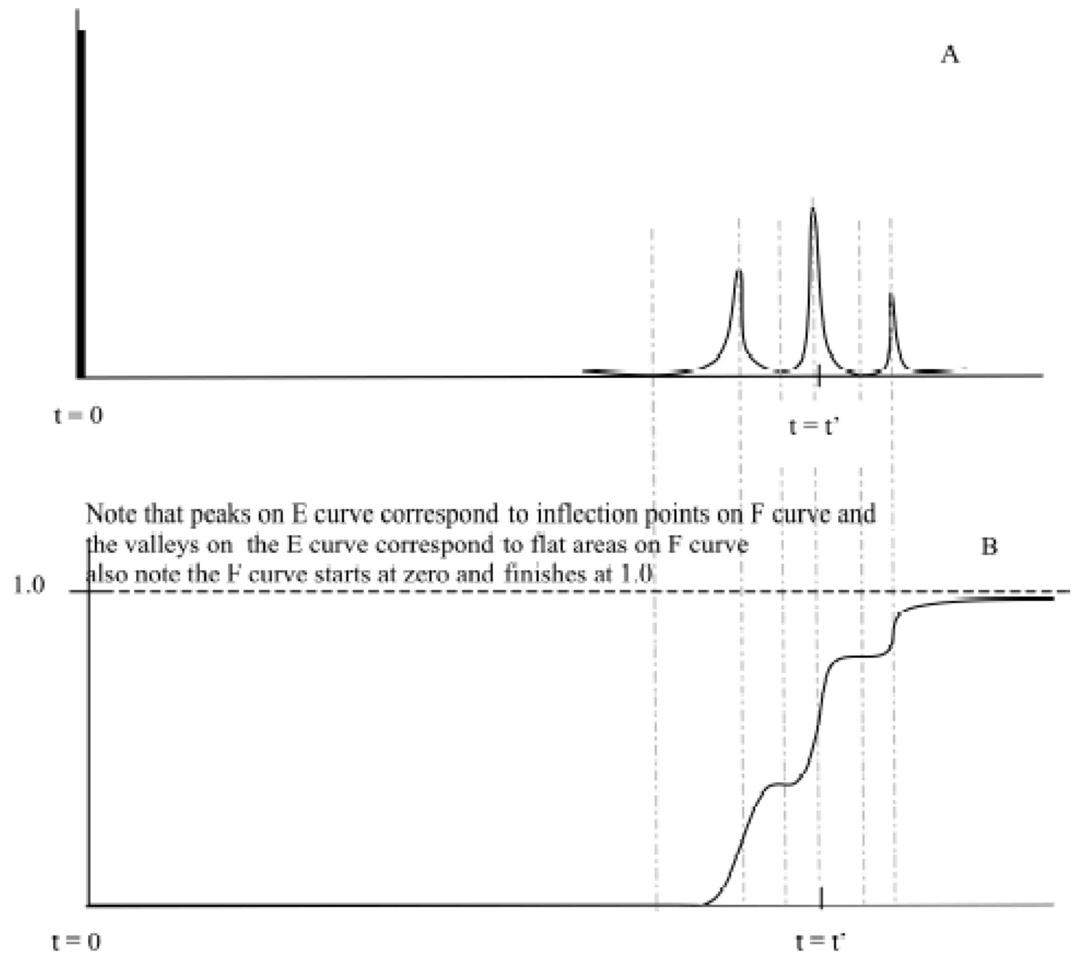
Problem 1

The A graph is basically an E(t) curve and the B graph is the corresponding F(t) curve.



Problem 2

2nd order MFRs in series

$q := 12\frac{L}{min}$ $\quad VA := 250L$ $\quad VB := 50L$ $\quad k := 0.025\frac{L}{min \cdot mol}$

$Co := 19.72\frac{mol}{L}$ $\quad tauA := \frac{VA}{q}$ $\quad tauB := \frac{VB}{q}$

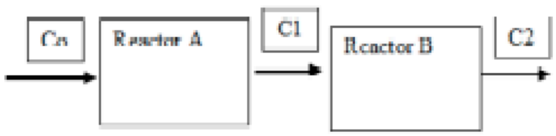
reactor A first

$tauA = 20.833\,min$ $\quad tauB = 4.167\,min$

$$C1A := \frac{1}{4 \cdot tauA \cdot k} \cdot \left(-2 + 2\cdot\sqrt{1 + 4 \cdot tauA \cdot k \cdot Co}\right) \qquad C2A := \frac{1}{4 \cdot tauB \cdot k} \cdot \left(-2 + 2\cdot\sqrt{1 + 4 \cdot tauB \cdot k \cdot C1A}\right)$$

$$XAB := \frac{Co - C2A}{Co}$$

$C1A = 5.268\frac{mol}{L}$ $\quad C2A = 3.78\frac{mol}{L}$



$XAB = 0.808$

reactor B first

$$C1B := \frac{1}{4 \cdot tauB \cdot k} \cdot \left(-2 + 2\cdot\sqrt{1 + 4 \cdot tauB \cdot k \cdot Co}\right) \qquad C2B := \frac{1}{4 \cdot tauA \cdot k} \cdot \left(-2 + 2\cdot\sqrt{1 + 4 \cdot tauA \cdot k \cdot C1B}\right)$$

$$XBA := \frac{Co - C2B}{Co}$$

$C1B = 9.772\frac{mol}{L}$ $\quad C2B = 3.477\frac{mol}{L}$

$XBA = 0.824$

Clearly, having reactor B first gives a better overall conversion.
The reason for this is that ideal MFR operate at the outlet concentraion,
hence the rate of reaction is at the outlet concentration.
To get the best performance, the reactors should be configures such that
the smaller reactor is first, which allows it to operate at a higher outlet concentration.

Problem 3

$$E(t) := a + b\cdot t + c\cdot t^2 + d\cdot t^3$$

$$Cout := \int C\cdot E(t)\, dt$$

zero order $\quad C := Co - k\cdot t$

$$Cout := \int (Co - k\cdot t)\cdot E(t)\, dt$$

$$X := 1 - \frac{Cout}{Co}$$

$$X := 1 - \frac{\int (Co - k\cdot t)\cdot E(t)\, dt}{Co} = 1 - \int \left(1 - \frac{k\cdot t}{Co}\right)\cdot E(t)\, dt$$

For a 1st order reaction with inlet Co $\quad C := Co\cdot e^{-k\cdot t}$

$$Cout := \int Co\cdot e^{-k\cdot t}\cdot E(t)\, dt$$

$$X := 1 - \frac{Cout}{Co}$$

$$X := 1 - \frac{\int Co\cdot e^{-k\cdot t}\cdot E(t)\, dt}{Co} = 1 - \int e^{-k\cdot t}\cdot E(t)\, dt$$

2nd order reaction $\quad C := \frac{Co}{Co\cdot k\cdot t + 1}$

$$Cout := \int \frac{Co}{Co\cdot k\cdot t + 1}\cdot E(t)\, dt$$

$$X := 1 - \frac{Cout}{Co}$$