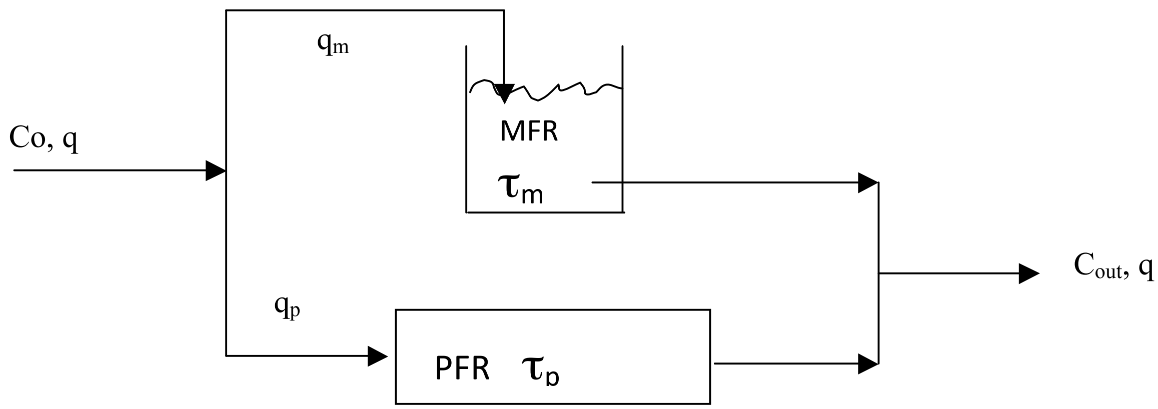
Problem 1.

Derive the equation giving C_{out} as a function of Co, q_m, q_p, τ_m, τ_p, and k, assuming an zero order reaction occurs in the ideal reactors of this steady state system.



Assume outlet concentrations of each reactor are C_m and C_p, respectively.
The performance equations for each reactor are:

$\tau_m = (C_o-C_m)/k$ $\qquad$ $\tau_p = (C_o-C_p)/k$

$C_m = C_o- k\tau_m$ $\qquad$ $C_p = C_o- k\tau_p$

The mass balance around the mixing point gives

$(q_mC_m + q_pC_p)/(q_m +q_p) = C_{out}$

Re-arranging and substituting for C_m amd C_p gives

$C_{out} = [q_m(C_o- k\tau_m) + q_p(C_o- k\tau_p)]/(q_m +q_p)$

Problem 2.

An enzymatic reaction is conducted in 2 ideal reactors in series (1 mfr, 1 pfr).

Data:

Km = 10 mol/L Vm = 5 mol/L-min Co = 100 mol/L q = 15 L/min

MFR volume = 300 L PFR volume = 150 L

a. Calculate the overall conversion if the MFR is first.

b. Calculate the overall conversion if the PFR is first.

M-M

Mixed reactor $-r_A = \dfrac{V_m C_A}{K_m + C_A}$

$$\tau_m = \frac{C_{A0} - C_A}{-r_A} = \frac{C_{A0} - C_A}{\dfrac{V_m C_A}{K_m + C_A}}$$

$$= \frac{(C_{A0} - C_A)(K_m + C_A)}{V_m C_A}$$

$$= \frac{C_{A0} K_m + (C_{A0} - K_m) C_A - C_A^2}{V_m C_A}$$

$$= \frac{C_{A0} K_m + (C_{A0} - K_m) C_{A0}(1 - X_A) - C_{A0}^2 (1 - X_A)^2}{V_m C_{A0} (1 - X_A)}$$

$$= \frac{K_m}{V_m} \frac{1}{(1 - X_A)} + \frac{C_{A0} - K_m}{V_m} - \frac{C_{A0}(1 - X_A)}{V_m}$$

m-m

PFR

$$\tau_p = \int \frac{dC_A}{r_A} = \int -\frac{dC_A (K_m + C_A)}{V_m C_A}$$

$$= -\frac{K_m}{V_m} \ln\left(\frac{C_A}{C_{A0}}\right) - \frac{1}{V_m}(C_A - C_{A0})$$

$$= \frac{K_m}{V_m} \ln\left(\frac{1}{1-X_A}\right) + \frac{1}{V_m} C_{A0} X_A$$

Part 2 a, MFR first

$C1m = 27.016$

$C2p = 2.181$

$$X1 := \frac{Co - C2p}{Co}$$

$X1 = 0.978$

Part 2 b. PFR first

$C1p = 55.829$

$C2m = 8.858$

$$X2 := \frac{Co - C2m}{Co}$$

$X2 = 0.911$

Problem 3.

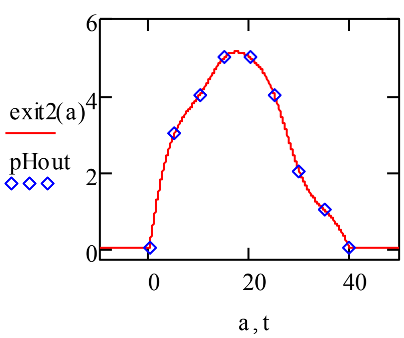
A pulse tracer of dye is injected into the product stream of a reactor. The color of the output stream is recorded at five second intervals.
Plot the E(t) curve for this system.

Please refer to the example 11.1 in text.

$$t := \begin{pmatrix} 0 \\ 5 \\ 10 \\ 15 \\ 20 \\ 25 \\ 30 \\ 35 \\ 40 \end{pmatrix} \qquad pHout := \begin{pmatrix} 0 \\ 3 \\ 4 \\ 5 \\ 5 \\ 4 \\ 2 \\ 1 \\ 0 \end{pmatrix}$$

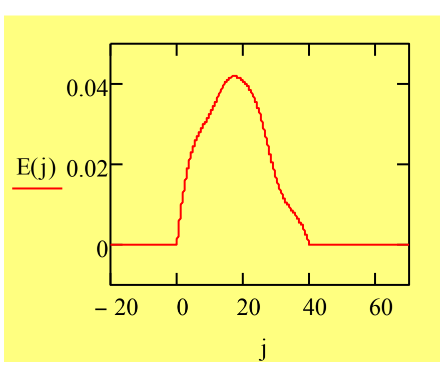
$$\text{Area} = \sum C\,\Delta t$$

$$\mathbf{E} = \frac{C}{\text{area}}$$



Find area under curve= 120

Normalize to get the E(t) curve to area = 1.



E curve