Written Homework #6
ChE 231
Spring 2019

Problem 1. Consider the matrix:

$$\mathbf{A} = \begin{bmatrix} 1 & 1 & 0 \\ 0 & 2 & 0 \\ 0 & -1 & 4 \end{bmatrix}$$

1. Calculate the eigenvalues.
2. Calculate the eigenvectors.
3. Use the modal matrix $\mathbf{X}$ to diagonalize the matrix $\mathbf{A}$.

Problem 2. Consider an isothermal, continuous stirred tank reactor in which the following irreversible reaction occurs: $A \rightarrow B$. Let C_A and C_B denote the molar concentrations of the reaction species. The reaction rate constant is denoted k, and the reaction rate per unit volume is: $r = kC_A$. Let V denote the constant reactor volume, and q denote the volumetric flow rate of the inlet and outlet streams. The reactor is fed with pure component A at a molar concentration C_{Af}. Consider the following constant operating conditions: $C_{Af} = 1$, and $V = 1$. To determine the unknown reaction rate constant k, steady-state experiments was performed at three different volumetric flow rates. The following data $\{\bar{q}, \bar{C}_A\}$ was obtained: $\{0.5, 0.35\}$, $\{1.0, 0.45\}$, $\{2.0, 0.70\}$. Steady-state component balances combined with the experimental data yield the following overdetermined set of linear algebraic equations:

$$\begin{bmatrix} 0.350 \\ 0.450 \\ 0.700 \end{bmatrix} k = \begin{bmatrix} 0.325 \\ 0.550 \\ 0.600 \end{bmatrix}$$

1. Formulate and analytically solve the least-square parameter estimation problem to obtain an estimate of k.
2. Compare the least-squares estimate of k to the estimates obtained from each individual experiment and the estimate obtained as the average of the individual estimates.