ChEE 413
Fall 2005
Homework Handout 6

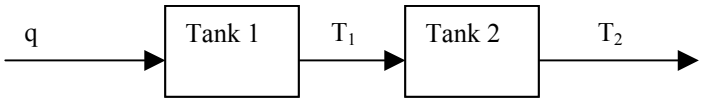
1) Problem 6.9 from Edition 1
The following transfer function has been widely used as an approximate mathematical model for many types of processes:

$$\frac{Y(s)}{X(s)} = \frac{Ke^{-\phi s}}{(\tau_1 s + 1)(\tau_2 s + 1)}$$

where Y is the output variable, X is the input variable, and K, τ_1, τ_2 and φ are constants. Determine the output response y(t) to a step change in input of magnitude = 3 when K = 1.5, τ_1 = 10 min, τ_2 = 20 min and φ = 3 min. Recall the Pade approximation.

2) Problem 7.3 from Edition 1

A process consists of two stirred tanks with input q and outputs T_1 and T_2, see the block diagram below.



To test the hypothesis that the dynamics in each tank are basically first order, a step change in q is made from 82 to 84, with out put results given in the table here:

Time	T_1	T_2	Time	T_1	T_2	Time	T_1	T_2
0	10	20.00	8	17.44	25.38	16	17.96	25.96
1	12.27	20.65	9	17.60	25.55	17	17.97	25.97
2	13.89	21.79	10	17.71	25.68	18	17.98	25.98
3	15.06	22.83	11	17.80	25.77	19	17.99	25.98
4	15.89	23.68	12	17.85	25.84	20	17.99	25.99
5	16.49	24.32	13	17.89	25.88	50	18.00	26.00
6	16.91	24.79	14	17.92	25.92			
7	17.22	25.13	15	17.95	25.94			

a) By means of the fraction incomplete response method, find the transfer function $T_1'(s)/Q'(s)$ and $T_2'(s)/T_1'(s)$. Assume they are of the form $K_i/(\tau_i s+1)$
b) Obtain an approximate differential equation relating T_1 to q and one relating T_2 to q.
c) Solve both equations for the same step change in q and plot the result along with the experimental data. Indicate how well the equations model the process.

3) Problem 7.4 from the first edition
For a process described by the transfer function:

$$G(s) = \frac{2}{(6s + 1)(4s + 1)(2s + 1)}$$

Calculate the response to a step input change of magnitude = 1.5 and then plot the output as a function of time.
a) Obtain an approximate first-order plus delay model using the fraction incomplete response method from the resulting data.
b) Find an approximate second-order model also from the resulting data.
c) Calculate the responses of both approximate models using the same step input as for the third-order model. Plot all three responses on the same graph. What do you conclude concerning the approximation?