CHBE 470 – Process Dynamics and Control – Fall 2007

Homework Set 3

Assigned: Wednesday, September 19 **Due:** Wednesday, September 26

Note: Please staple your papers and include your name in the first page

Use table 7.1 from textbook wherever you find appropriate

Problem 1: A process of unknown transfer function is subjected to a unit-impulse input. The output of the process is measured accurately and is found to be represented by the function $y(t)=te^{-t}$. Determine the transfer function of the system.

Problem 2: Consider a liquid storage tank with a nonlinear resistance in the outlet flow rate ($F = 8\sqrt{h}$, h=liquid level) and with cross-sectional area of Area A=3 ft^2. Calculate the time constant for this system (after linearization) if the operating liquid level is a) 3 ft and b) 9ft.

Problem 3: Consider an isothermal CSTR where the following reaction is taking place:

$$A \xrightarrow{k} B \tag{3.1}$$

Let F_i, and c_{Ai} respectively denote the volumetric flow rate (lt/h) and the concentration of A (mol/lt) in the inlet stream. Moreover, F and c_A represent the volumetric flow rate (lt/h) and the concentration of A (mol/lt) in the outlet streams. Let, also, $r=kc_A$ be the volumetric reaction rate (moles A reacting/lt/h). Assuming 1) constant density ρ, reactor volume V and temperature T, as well as 2) that the feed stream is composed of pure A, derive the transfer function relating the concentration c_A in the reactor to the feed stream concentration c_{Ai}. Sketch the response of the system to a unit-step change, a unit-impulse change and a sinusoidal input $A\sin(\omega t)$.

Problem 4: Consider a liquid storage tank, where Fi and F respectively denote the volumetric flow rates of the inlet and outlet streams and assume that:

a) $$F_i = F_{is} + a\sin(\omega t) \tag{4.1}$$

where a and w are known constants while F_{is} is the nominal steady-state value

b) $$F = \frac{1}{R}h \tag{4.2}$$

where R is a known constant resistance and h is the liquid level. What should be the cross-sectional area A of the tank so that the fluctuation of the outlet flow rate is a fraction b of the fluctuation of the inlet flow rate?