CHBE 470 – Process Dynamics and Control – Fall 2007

Homework Set 2

Assigned: Wednesday, September 12 **Due:** Wednesday, September 19

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

Use table 7.1 (pages 137-138) from textbook wherever you find appropriate

Problem 1: Consider a liquid storage tank with a nonlinear resistance in the outlet flow rate ($F = 20\sqrt{h}$, h=liquid level), with the following values for the process parameters:
Area A=1 ft^2,
Steady state liquid level h_s=9ft,
Steady state for the inlet flow rate F_s=60 ft^3/min

- **a)** Compute and plot the response of the nonlinear and linearized process models for i) 10% decrease in the inlet flow rate and ii) 85% decreases in the inlet flow rate *(Use ode45 from Matlab to compute the solution to the nonlinear ODE)*
- **b)** Comment on the nature of the responses for the two cases and the validity of the linearized process model.

Problem 2: Calculate the Laplace transform of the function: $f(t) = (t-1)^2$

Problem 3: Find the time-domain solution for the following differential equation using Laplace transforms:

$$\begin{aligned} &\frac{d^2x}{dt^2} + 5\frac{dx}{dt} + 6x = u(t) \\ &\frac{dx}{dt}(0) = x(0) = 0 \end{aligned} \tag{3.1}$$

where u(t) is the unit ramp function. Before you invert, comment on the qualitative nature of the solution asymptotically in terms of possible oscillatory, convergent or divergent behavior and calculate the final value.

Problem 4: Find the time-domain solution for the following differential equation using Laplace transforms:

$$\begin{aligned} &\frac{d^4x}{dt^4} + \frac{d^3x}{dt^3} = \cos t \\ &x(0) = \frac{dx}{dt}(0) = \frac{d^3x}{dt^3}(0) = 0, \frac{d^2x}{dt^2}(0) = 1 \end{aligned} \tag{4.1}$$

Before you invert, comment on the qualitative nature of the solution asymptotically in terms of possible oscillatory, convergent or divergent behavior and calculate the final value.