CM 3310
Spring 2008
Project 1
Due: Feb. 1, 2008, 5pm

A non-isothermal CSTR process is described by the following equations (for details see page 641-649, please disregard the issues on transfer functions -- a future topic for our class) :

$$\frac{dC_A}{dt} = \frac{F}{V}\left(C_{Af} - C_A\right) - k_0 \exp\left(\frac{-E_a}{R(T+460)}\right) C_A \qquad \text{(Eqn 1a)}$$

$$\frac{dT}{dt} = \frac{F}{V}\left(T_f - T\right) + \left(\frac{-\Delta H}{\rho C_p}\right) k_0 \exp\left(\frac{-E_a}{R(T+460)}\right) C_A - \left(\frac{UA}{V\rho c_p}\right)\left(T - T_j\right) \qquad \text{(Eqn 1b)}$$

with the following values for the constants, design parameters and process parameters (please note that these values are loosely based on those given on page 647 of your book but some numbers have been changed) :

F	volumetric flow rate	3000 ft^3/hr
V	liquid volume	750 ft^3
T_f	temperature of feed	60^{o}F
C_{Af}	concentration of A in feed	0.132 lbmol/ft^3
ΔH	molar heat of reaction	-45000 BTU/lbmol
ρc_p	heat capacity per volume	33.2 Btu/(ft^3 ^{o}F)
U	heat transfer coefficient	75 Btu/(hr ft^2 ^{o}F)
A	area for heat transfer	1221 ft^2
k_0	Arrhenius frequency factor	15 x 10^{12} $hr^{(-1)}$
E_a	activation energy	32400 Btu/(lbmol ^{o}F)
R	universal gas constant	1.987 Btu/(lbmol ^{o}R)

1. Multiple Steady States

   Using the jacket temperature, T_j, as the manipulated variable, set to 55^{o}F, determine the three steady states, i.e. three pairs of values for ($C_{A,ss}$, T_{ss}).

2. Linearization

   Obtain a linearized set of equations for dC_A/dt and dT/dt operating at each of the steady states found in the previous number.

3. Stability Prediction

   Using the linearized set of equations found, predict the stability of operating around that steady state using the eigenvalues.

4. Simulation

Verify the predictions by simulating the process using original set of nonlinear differential equations (equations 1 and 2 above), and obtain time plots of C_A and T using the following initial conditions:

$C_A(0)$ (lbmol/ft^3)	$T(0)$ (^{o}F)
0.132	70.00
0.090	92.84
0.080	96.20
0.028	139.2

(Gather together on one plot the responses of C_A based on different initial conditions. Do the same with the response of T).