ชื่อ_____ **รหัส**_____

PRINCE OF SONGKLA UNIVERSITY

FACULTY OF ENGINEERING

Midterm Examination: Semester I Academic year: 2004

Date: 8, August 2004 Time: 9.00 – 12.00

Subject: 230 – 425 Process Dynamics and Control Room: A 401

ทุจริตในการสอบ โทษขั้นต่ำ คือ ปรับตกในรายวิชาที่ทุจริต และพักการเรียน 1 ภาคการศึกษา

- ข้อสอบมีทั้งหมด 4 ข้อ รวม 6 หน้าไม่รวมปก และหน้าแสดงตาราง Laplace Transform and Inverse (i) ให้นักศึกษาตรวจสอบความเรียบร้อย เขียนชื่อและรหัสทุกหน้าก่อนลงมือทำข้อสอบ

- อนุญาตให้นำกระดาษจดบันทึกขนาด A4 เข้าได้ 1 แผ่นเท่านั้น
- อนุญาตให้ทำข้อสอบด้านหลังได้

ข้อ	คะแนนเต็ม
1	35
2	30
3	55
4	60
รวม	180

อาจารย์กุลชนาฐ กปิลกาญจน์

ผู้ออกข้อสอบ

Laplace Transform Table

$f(t)$	$F(s)$
t^n	$\frac{n!}{s^{n+1}}$
e^{at}	$\frac{1}{s-a}$
$\sin kt$	$\frac{k}{s^2+k^2}$
$\cos kt$	$\frac{s}{s^2+k^2}$
$e^{at}\sin kt$	$\frac{k}{(s-a)^2+k^2}$
$e^{at}\cos kt$	$\frac{s-a}{(s-a)^2+k^2}$
$\sinh kt$	$\frac{k}{s^2-k^2}$
$\cosh kt$	$\frac{s}{s^2-k^2}$
1	$\frac{1}{s}$
$\delta(t-a)$	e^{-as}
$e^{at}f(t)$	$F(s-a)$
$f'(t)$	$sF(s)-f(0)$
$f^{(n)}(t)$	$s^nF(s)-s^{n-1}f(0)-s^{n-2}f'(0)-\cdots-f^{(n-1)}(0)$
$t^nf(t)$	$(-1)^nF^{(n)}(s)$
$f(t+T)=f(t)$	$\frac{\int_0^T e^{-st}f(t)\,dt}{1-e^{-sT}}$
$f(t-a)U(t-a),\ a\geq 0$	$e^{-as}F(s)$
$f(t)U(t-a),\ a\geq 0$	$e^{-as}\mathcal{L}[f(t+a)]$
$U(t-a)$	$\frac{e^{-as}}{s}$
$\int_0^t f(\tau)\,d\tau$	$\frac{F(s)}{s}$
$f*g(t)=\int_0^t f(\tau)g(t-\tau)\,d\tau$	$F(s)G(s)$

`Name_____Code_____

1. [35 points] Consider exothermic reaction: A → B in the continuous stirred tank reactor (CSTR) shown in Figure 1

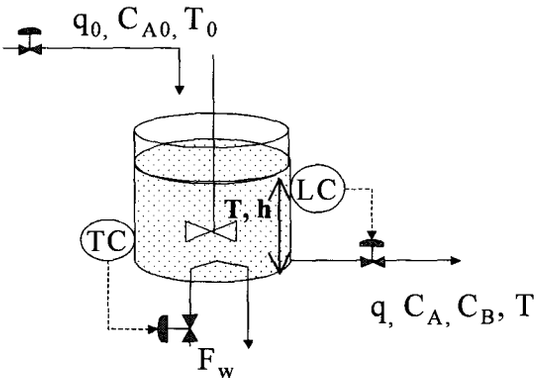

Figure 1

q_o = volumetric flow rate fed to the CSTR

C_{A0} = concentration of A in the feed

T_o = feed temperature

q = volumetric effluent flow

C_A = concentration of A in the effluent

C_B = concentration of B in the effluent

T = effluent temperature

F_w = cooling water flow rate

h = reactor level

a). From the figure what are disturbance(s), controlled and manipulated variable(s)? [5]

Disturbance(s)_____

Controlled variable(s)_____

Manipulated variable(s)_____

b). If the downstream wants to get more product B and still maintain the reactor level,

b1). Can we use the same control structure as shown in Figure 1, why? [10]

_____

_____

_____

b2). The control valve for cooling water F_w should be opened or closed, why? [10]

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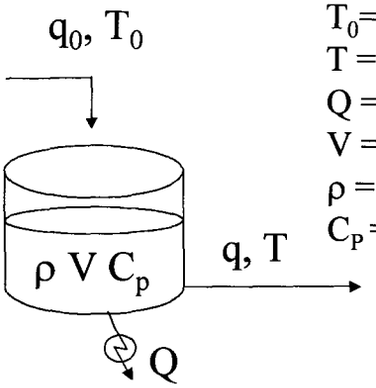
_____

_____

b3). Modify figure 1 for problem b). Sketch the control structure **with feed forward and/or feed back controllers** and define variables in the structure (controlled, manipulated variables and disturbance). [10]

`Name_____Code_____

2. [30 points] Consider mass and energy balances in the tank



q_0, = volumetric flowrate of the input
q = volumetric flowrate of the output
T_0= input temperature
T = output temperature
Q = heat removal
V = tank volume
ρ = constant liquid density
C_P = constant liquid heat capacity

a) Derive the mass and heat balance equations [10]

b) From the equations, Analyze the degrees of freedom. What are the following?: [10]

- Number of the equations N_E =_____
- parameters (constants):_____
- Variables (N_V =_____) :_____
- Degrees of Freedom = _____

c) From part b), is the problem can be solved? Why? [10]

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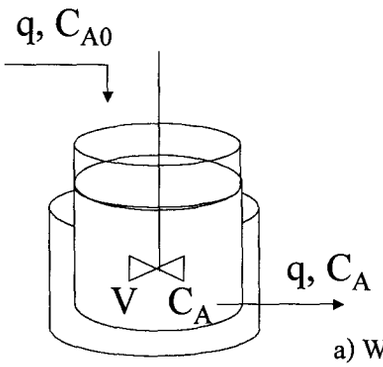
3 [55 points] Consider isothermal CSTR constant volume. IF a reaction A→B is a second order with

$r_A = -kC_A^2$. (k is constant)



q = volumetric flow rate of the feed and effluent

C_{A0} = concentration of A in the feed

C_A = concentration of A in the reactor and the effluent

a) Write the component A balance [10]

b) Linearize the equation in a) if needed and find the perturbation variable [15]

c) Use the Laplace transform to find the result (final concentration of A) when **C_{A0} increases 5%.** [25]

d) If using Final value theory, will you get the same solution as in c) ? and Show that. [5]

4 [60 points]The liquid tank system is shown below:

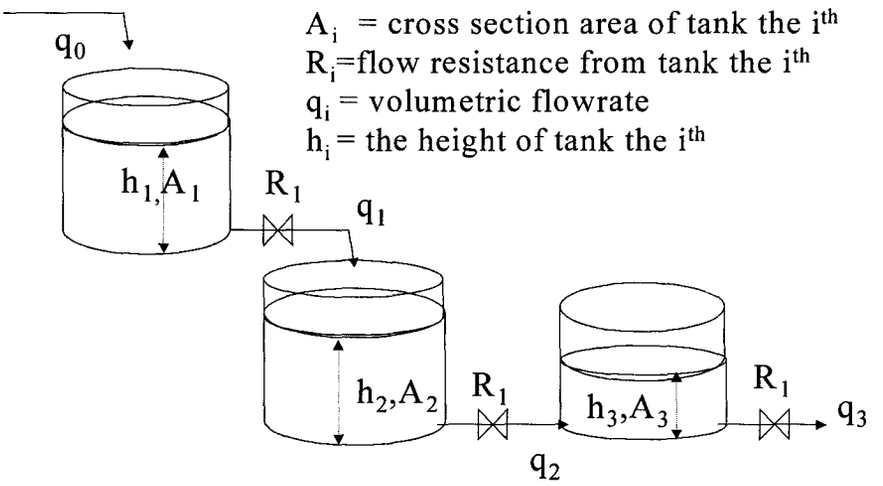
a) To simplify the model, what are the assumptions used in this model besides the given parameters? [5]

b) What is a mathematical model for material balance of this system with your assumptions in (a). [10]

c) Find the perturbations variables of this systems with 3 tanks [10]

d) Find the transfer functions for the perturbation of $G1=Q_3(s)/Q_0(s)$ และ $G2=H_3(s)/Q_0(s)$. If the change in $Q_0(s)$ is unit step function, what are the response and the final value of $H_3(t)$ [25]

e) IF liquid in tank 2 and 3 are considered, what are the damping factor $G_3(s) =Q_3(s)/Q_1(s)$? [10]



Note Let $q = h/R$