PRINCE OF SONGKLA UNIVERSITY
FACULTY OF ENGINEERING

Midterm Examination: Semester I	Academic year: 2005
Date: 7 August 2005	Time: 9.00-12.00
Subject: 230 – 425 Process Dynamics and Control	Room: R201

ทุจริตในการสอบ โทษขั้นต่ำ คือ ปรับตกในรายวิชาที่ทุจริต และพักการเรียน 1 ภาคการศึกษา

- **Only hand written note in 1 A4 and a dictionary are allowed.**
- There are 5 pages of the exam not include the cover page and given data page.
- Write your name or at least your code on each page.
- If need to write the answers on the back of each page, please identify the problem number.
- Write explanations clearly and concisely will be your advantage.

Name____________________________**code**____________________

Problem Number	Score
1	20
2	20
3	60
4	60
5	20
Total	180

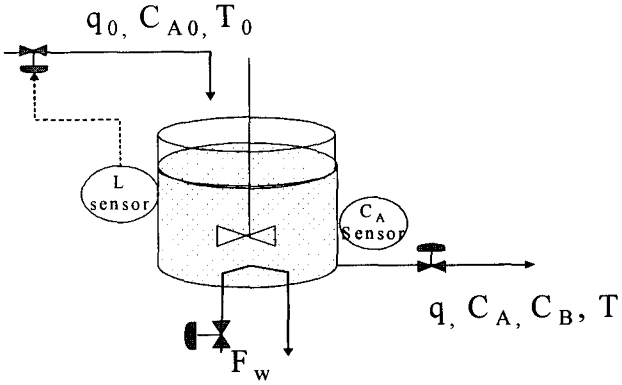
Dr. Kulchanat Kapilakarn

Laplace thransform

F(s)	f(t), t > 0
$Y(s) = \int_0^\infty \exp(-st) y(t) dt$	y(t)
Y(s)	$y(t) = \frac{1}{j2\pi} \int_{c-j\infty}^{c+j\infty} \exp(st) Y(s) ds$
$s^n Y(s) - s^{n-1}[y(0)]$ $- s^{n-2}[y'(0)] - \cdots - s[y^{(n-2)}(0)]$ $-[y^{(n-1)}(0)]$	$y^{(n)}(t)$
F(s) / s	$\int_0^t Y(\tau) d\tau$
F(s)G(s)	$\int_0^t f(t-\tau) g(\tau) d\tau$
$\frac{1}{\alpha} F\left(\frac{s}{\alpha}\right)$	$f(\alpha t)$
$F(s-\alpha)$	$\exp(\alpha t) f(t)$
1	$\delta(t)$
$\exp(-\alpha s), \ \alpha \geq 0$	$\delta(t-\alpha)$
1/s	u(t)
$1/s \exp(-\alpha s)$	$u(t-\alpha)$
$1/s^2$	t
s^{-n} n =1, 2, 3,…	$t^{n-1} / (n-1)!$
$n!/ s^{n+1}$ n=1, 2, 3,…	t^n
$\frac{1}{(s+\alpha)^n}$, n=1, 2, 3,….	$\left[\frac{t^{n-1}}{(n-1)!}\right] \exp(-\alpha t)$
$\frac{\alpha}{s^2+\alpha^2}$	$\sin(\alpha t)$
$\frac{s}{s^2+\alpha^2}$	$\cos(\alpha t)$
$\frac{1}{s^2-\alpha^2}$	$\frac{1}{\alpha} \sinh(\alpha t)$
$\frac{s}{s^2-\alpha^2}$	$\cosh(\alpha t)$

230-425 Midterm examination Name____________________ Code______________

1) (20 points)
The figure below shows the process of reducing concentration of A by the reaction A→B. L- sensor and C_A-sensor are sensors for level of liquid and concentration of A in the tank, respectively. Note: q is volumetric flowrate, C is concentration, T is temperature and F_w is volumetric flowrate of cooling water.



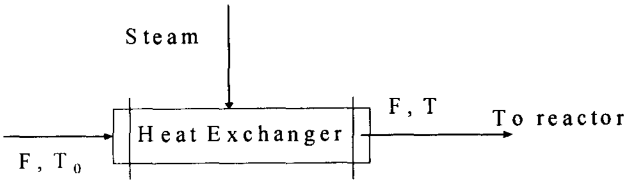
a). What are the objectives of the process and control objectives?

b). How many controlled variables are in the process?

c). Write controlled variables and their related manipulated and disturbance variables in each line of the given table (number of lines in the table depend on number of controlled variable, more or less lines can be adjusted). And classify each controlled variable is feedback or feedforward control.

Controlled variables	**Manipulated variables**	**Disturbance**	**Feedback or Feedforward control**

2) (20 points ☼)
The preheating unit in the plant makes the input stream from T_0 to T before feeding to the reactor. The figure below shows the preheating unit of the process. If T_0 is changed, how the engineer can control temperature of the heat exchanger output T?



a). Propose and sketch the figure by using feedback control.

b). Propose and sketch the figure by using feedforward control.

c). What are the advantages and disadvantages for feedback control and feed forward control? Fill the details in the table.

Control type	Advantage	Disadvantage
Feedback control		
Feedforward control		

3) (60 points 🔔🔔)

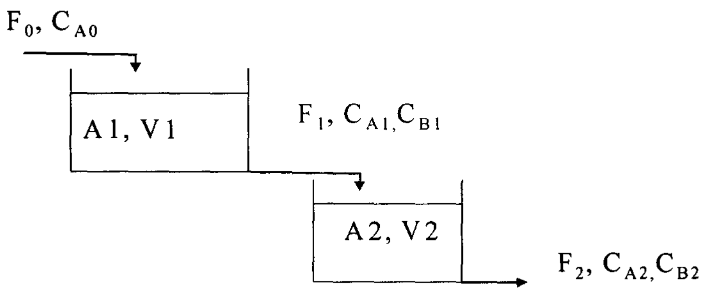
An isothermal, first order, liquid-phase, reversible reaction $A \underset{k2}{\overset{k1}{\Leftrightarrow}} B$ is carried out in a constant volume, perfectly mixed continuous reactor. The concentration of product B is zero in the feed and is C_B in the reactor. The feed flowrate is F.

a). Derive a mathematical model describing the dynamic behavior of the system.

b). Assuming that the reactor is at this steady-state concentration and that a step change is made in C_{A0} to $(C_{A0} + \Delta C_{A0})$, find the final concentrations of A and B.

4) (60 points)

Two isothermal CSRTs in series for reaction A → B. Assume first order reaction with a reaction rate constant "k". The concentration of A and B in both reactors are zeros at the beginning. Each reactor tanks keep volume constant at V1 and V2, respectively.



a). Find process transfer function $C_{A2}(s) / C_{A0}(s)$ (use perturbation variables).
b). What are process gain, process damping factor and process time constant?
c). Determine concentration of C_{A2} when the process is critically damped with unit step change in C_{A0}.

5) (20 Points)

Find a transfer function of closed loop response for C(s)/ R(s) shown in the figure below.