230-425 Midterm Name________________________Code_____

PRINCE OF SONGKLA UNIVERSITY
FACULTY OF ENGINEERING

Midterm Examination: Semester I Academic year: 2006
Date: 6 August 2006 Time: 9.00-12.00
Subject: 230 – 425 Process Dynamics and Control Room: A401

ทุจริตในการสอบ โทษขั้นต่ำ คือ ปรับตกในรายวิชาที่ทุจริต และพักการเรียน 1 ภาคการศึกษา

- **Only hand written note in 1 A4 and a dictionary are allowed.**
- There are 8 pages of the exam.
- 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.
- Calculator, Dictionary and hand-written in 1 A4 are allowed.

Problem Number	Score	
1	20	
2	15	
3	35	
4	50	
5	45	
6	15	
Total	180	

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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-α)	exp(αt)f(t)
1	δ(t)
$\exp(-\alpha s), \ \alpha \geq 0$	$\delta(t-\alpha)$
1/s	u(t)
1/s exp(-αs)	u(t-α)
$1/s^2$	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,….	$\left[\frac{t^{n-1}}{(n-1)!}\right] \exp(-\alpha t)$
$\frac{\alpha}{s^2+\alpha^2}$	$\sin(\alpha t)$
$\frac{s}{s^2+\alpha^2}$	$\cos(\alpha t)$
$\frac{1}{s^2-\alpha^2}$	$\frac{1}{\alpha} \sinh(\alpha t)$
$\frac{s}{s^2-\alpha^2}$	$\cosh(\alpha t)$

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1 (20 points)

1.1 (10 points) From Figure 1A, please answer the questions

a. Controlled variable is _________ b. Disturbance is ___________

c. Manipulated variable is ____

d. Does the figure show feedback control or feed forward control? Give the reasons that make you select your answer.__________________________________

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Figure 1A

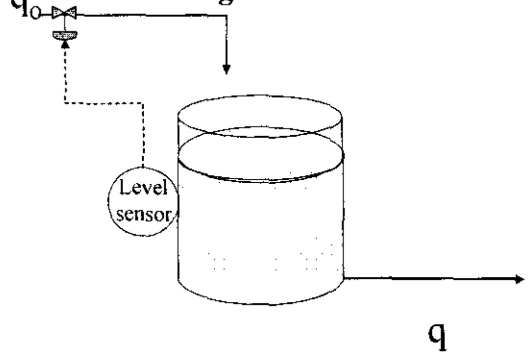
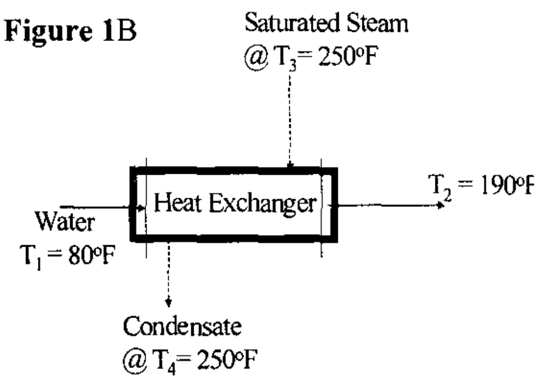
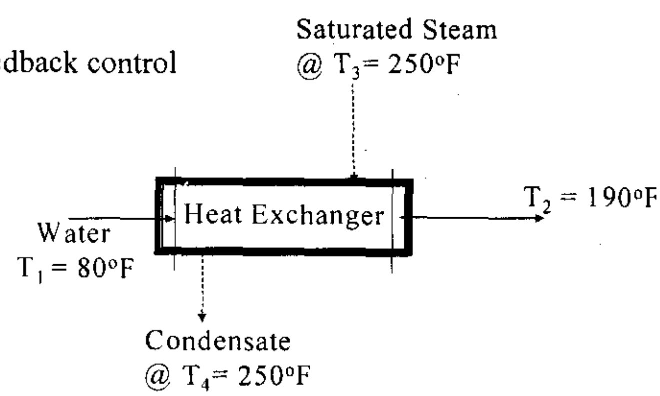


Figure 1B

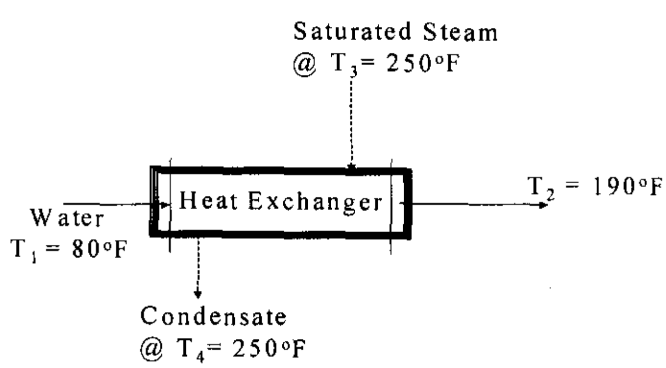


1.2 (10 points) From Figure 1B, consider the temperature T_2 = 190 °F is our basic control objective. Construct feedback and feed forward control configurations that will satisfy the control objective

Feedback control



Feed forward control



2. (15 points) A single-tank process has been operating for a long period of time with the inlet flow rate q_i = 30.4 ft^3/min. After the operator increases the flow rate suddenly by 10%, the liquid level in the tanks changes as shown in Figure 2

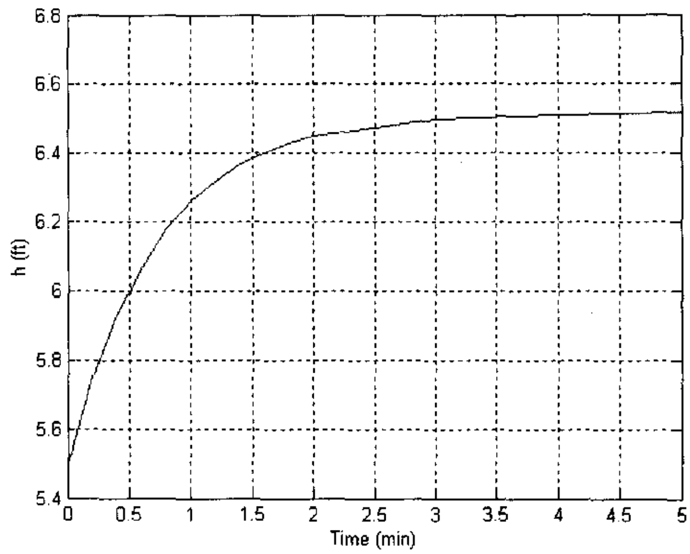


Figure 2 Display liquid level in a single-tank process

2.1 The order of the process is ________________

2.2 Does the process has transportation lag? If it has, what is the value of the lag?

2.3 Show the transfer function of the process

3. (35 points)

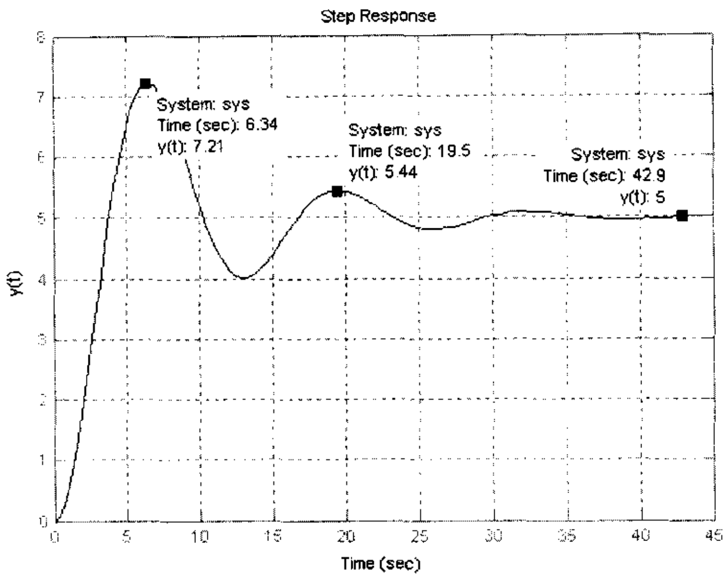


Figure 3 step response of the process

If step input is 2, determine the following variables:

3.1 Process gain ________________ 3.2 Overshoot ______________

3.3 Period ____

3.4 Damping factor

3.5 Process time constant

3.6 Process transfer function

4. (50 points) Two isothermal CSTRs are connected by a long pipe that acts as pure deadtime of D minutes at the steady-state flow rate. Assume constant throughput and holdups and first-order irreversible reaction A→B with reaction rate constant k in each tank.

4.1. Derive the transfer function relating the feed concentration to the first tank, C_{A0}, and the concentration of A in the stream leaving the second tank, C_{A2}.

4.2 Find $C_{A2}(0)$, $C_{A2}(t=\infty)$ and $C_{A2}(t)$ for a unit step disturbance in C_{A0}

5. (50 points) Figure 4 shows 2-tank process with constant liquid density. If F_0, F_1 and F_2 are volumetric flow rates, A1, V1, A2 and V2 are cross section areas and liquid volumes of tank 1 and tank 2, respectively. If the relation of flow rate F1 and liquid level of tank 1 (h1) is $F1 = h1 / R1$ and for tank 2 is $F2 = \sqrt{h2} / R2$.

5.1 Determine $\frac{H2(s)}{F_0(s)}$

5.2 Show the damping factor of the transfer function from 5.1.

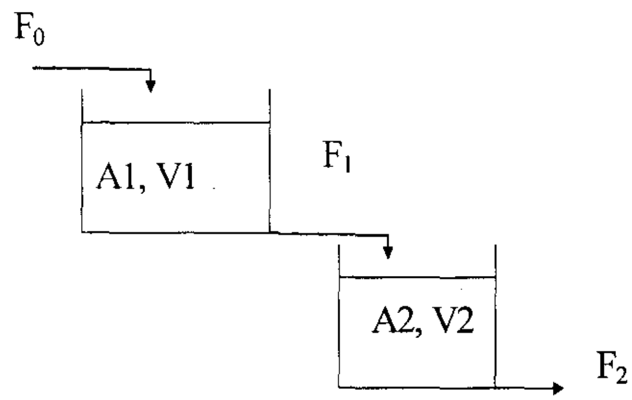


Figure 4

6. (15 points) Show transfer function of $\frac{X_1(s)}{X_0(s)}$ for the process in figure 5

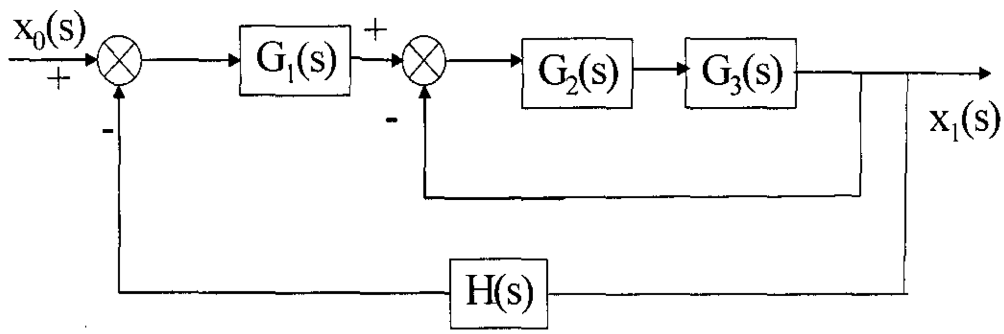


Figure 5