PRINCE OF SONGKLA UNIVERSITY
FACULTY OF ENGINEERING

Midterm Examination: Semester I — Academic year: 2007
Date: 5 August 2007 — Time: 9.00-12.00
Subject: 230 – 425 Process Dynamics and Control — Room: R300

ทุจริตในการสอบ โทษขั้นต่ำ คือ ปรับตกในรายวิชาที่ทุจริต และพักการเรียน 1 ภาคการศึกษา

- **Only hand written note in a sheet of A4 and a dictionary are allowed.**
- There are 9 pages of the exam.
- Write your name or your code on each page.
- If need to write the answers on the back of each page, please identify the problem number.

Problem Number	Score	
1	20	
2	40	
3	40	
4	20	
5	60	
Total	180	

Dr. Kulchanat Prasertsit

Table 1 Laplace Transform

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

1. (20 points)

1.1 (10 points) Write "**T**" for correct statement and "**F**" for false statement (2 points for the correct answers and **-1** point for incorrect answers)

a) ____Feed back control and feed forward control both require a measured variable.

b) ____The process variable to be controlled is measured in feedback control.

c) ____Feed forward control can provide perfect control: that is, the output can be kept at its setpoint even with an imperfect process model.

d) _____Feedback control will always take action regardless of the accuracy of any process model that was used to design it and the source of a disturbance.

e) _____Figure 1.1 is feed back control

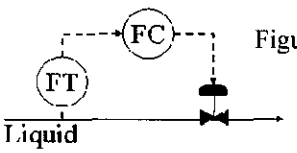


Figure 1.1

1.2 (10 points) "Fresh feed A and fresh feed B are fed to CSTR with the flow rate of F_A and F_B, respectively. For safety reason, the level of the tank should not less than 1/3 of the tank. And for economic reason, the concentration of x_C must be higher than 95%. At the moment the operator accidentally, opened valve for stream F_{Out} greater than its steady-state opening"

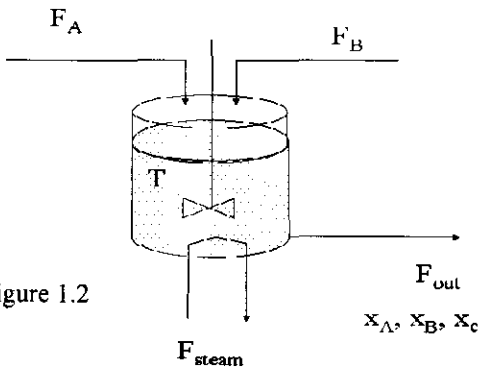


Figure 1.2

From the sentences classify all variables in the table below

Controlled variables	**Disturbance**	**Manipulated variables**

2. (40 points) The temperature of the mercury in mercury thermometer can be described in the following equation:

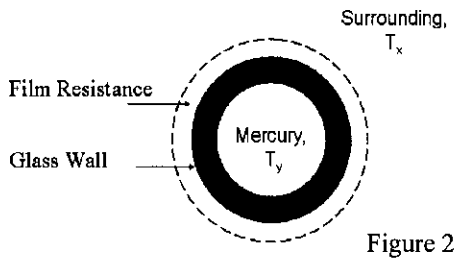


Figure 2

$$mC\frac{dT_y}{dt} = hA(T_x - T_y)$$

m = mass of mercury in bulb

C = heat capacity of mercury

h = film coefficient of heat transfer

2.1 (10 points) Show how to get the equation and assumptions used for this problem.

2.2 (15 points) From the differential equation, use Laplace transform and deviation variable to find transfer function of $T'_y(s) / T'_x(s)$.

2.3 (15 points) If the changing in surrounding temperature is ramp function; ($T_x = T_x + b*t$: $t \geq 0$), find $T'_y(t)$ and $T'_y(\infty)$

3. (40 points)

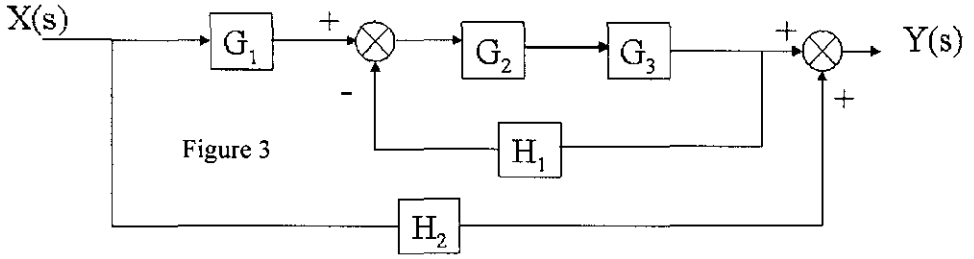


Figure 3

3.1 (15 points) Find transfer function of Y(s)/ X(s).

3.2 (10 points) Show characteristic equation of the process.

3.3 (15 points) If $G_1 = 1/(s+1)$, $G_2=(s+2)$, $G_3 = 1/(3s+1)$, $H_1 =1$ and $H_2 = 2$, Find system order and find the steady-state value of Y(s) when x(t) = 5s(t)

4. (20 points) Process Response

4.1 (10 points) The response of a liquid level in tank from a step change input is shown in the following figure. Answer the following question;

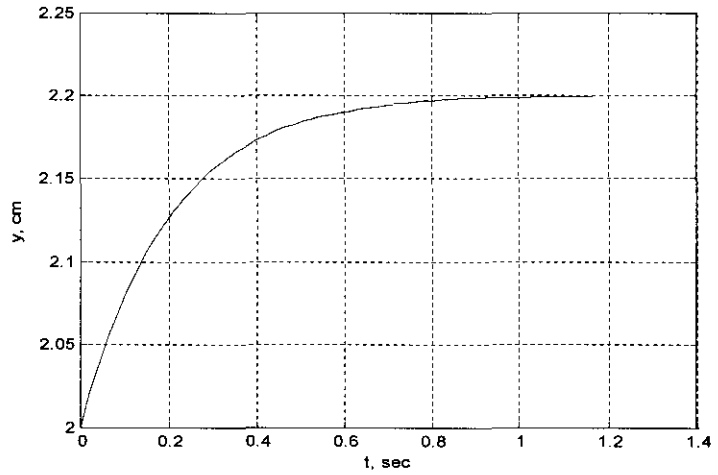


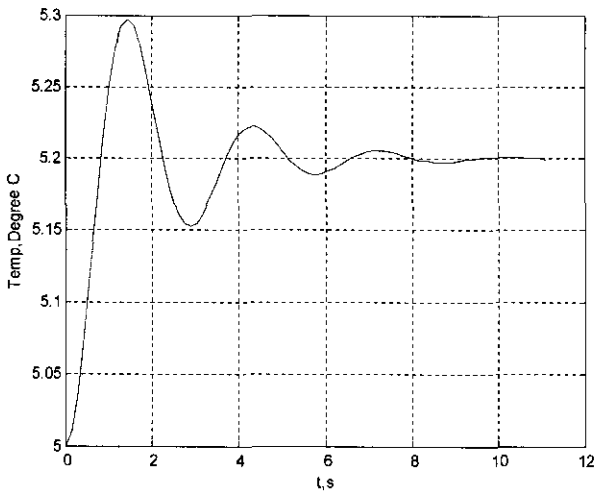
Figure 4.1

a) What is the order of the system_____

b) If the liquid input flow rate changes from 5 cm^3/s to 7 cm^3/s,

τ_p =_____, K_p =_____ Process Transfer function_____

4.2 (10 points) Figure 4.2 is the response of a tank temperature. The system is found as the 2nd-order. Answer the following question



a) Rise time =_____

b) % Overshoot =_____

c) Decay ratio = _____

d) Settling time =_____

e) Period =_____

5. (60 points) The process consists of 2-connecting tanks as shown in figure 5. Using deviation variables to

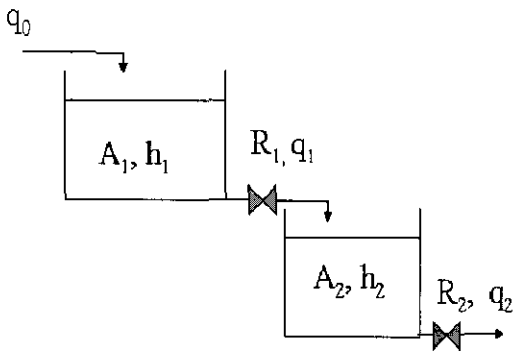


Figure 5

5.1 (30)Find transfer function ;

$$H_2'(s)/Q_o'(s)$$

5.2 (20) Determine the process order, damping factor, process time constant and process gain.

5.3 (10) Does the process stable if the change in q_o is step function? Explain your answer.

(Let $R_1 = h_1/ q_1$, $R_2 = h_2/\sqrt{q_2}$, q ≡ volumetric flow rate, A ≡ cross section area of each tank, h ≡ liquid level of each tank)