PRINCE OF SONGKLA UNIVERSITY
FACULTY OF ENGINEERING

Final Examination: Semester I Academic year: 2006
Date: 7 October 2006 Time: 9.00-12.00
Subject: 230 – 425 Process Dynamics and Control Room: A400

ทุจริตในการสอบ โทษขั้นต่ำ คือ ปรับตกในรายวิชาที่ทุจริต และพักการเรียน 1 ภาคการศึกษา

- **Only hand written note in 1 A4, a dictionary and Calculator 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.

Problem Number	Score	
Part I	20	
Part II		
1	30	
2	40	
3	40	
4	50	
Total	180	

Dr. Kulchanat Prasertsit

230-425 Final 2005 Name_____Code_____

Part I (20 points)

Mark X on the right answer (1 score for the right answer and -1 score for the wrong answer)

1. Gain margin is the most related to_____

1. BODE Plot 2. Root- Locus 3. Step response 4.Nichol 5.No answer

2. Arrange the following control system design concepts from the most importance to the least.

A. The best control system should have the accurate control equipments.

B. The control system designer should understand the process.

C. The best control system should be convenience and not expensive.

1. A, B, C 2. A, C, B 3. B, A, C 4. B, C, A 5. C, B, A

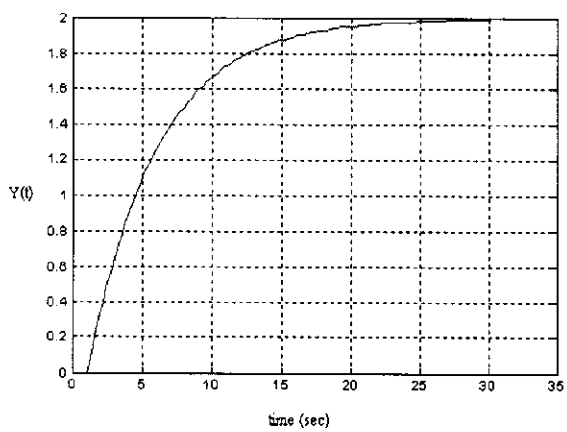
3. Which statement is correct?

1. If the open loop process response is stable, the closed loop response is stable.
2. If the open loop process response is stable, the closed loop response with controller is stable.
3. If the open loop process response is unstable, the closed loop response is unstable.
4. If the open loop process response is unstable, the closed loop response can be stable with appropriate controllers.
5. Can not conclude.

4. A temperature transmitter converts the temperature from 0-100 °C to electric current from 4 – 16 mA. What is the current when a process temperature is 40 °C?

1. 16 mA 2. 11.2 mA 3. 8.8 mA 4. 6.4 mA 5. 4 mA

5. From the figure, what are a process time constant and its dead time?

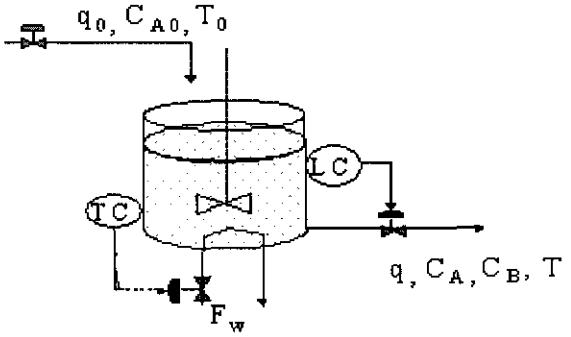


1. Process time = 1 s Dead time = 1 s
2. Process time = 25 s Dead time = 1 s
3. Process time = 6 s Dead time = 5 s
4. Process time = 5 s Dead time = 1 s
5. Process time = 25 Dead time = 5 s

6. Which answer is true for the system which $s^3+s^2- s-1 = 0$?

1. The system is unstable because of its higher order system.
2. The system is stable because all roots of the equation are negative.
3. The system is unstable because at lease one root is positive.
4. Can not tell whether the system is stable or not.
5. All are incorrect.

7. From the figure, what are controlled variable, manipulated variable and disturbance?



1. Controlled variable =T, L Manipulated variable = Fw, q Disturbance = T_0
2. Controlled variable =Fw, q Manipulated variable = T, L Disturbance = C_{A0}
3. Controlled variable =C_{A0}, T Manipulated variable = L, q Disturbance = q_0
4. Controlled variable = q, T Manipulated variable = Fw, C_A Disturbance = q_0
5. Controlled variable = q, L Manipulated variable = Fw, C_A Disturbance = q_0

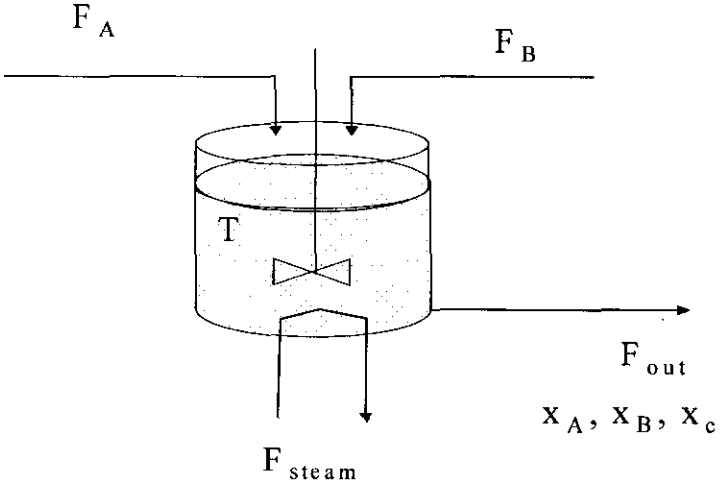
8. What is the transfer function of PI controller?
   1. $CO/(s)/ E(s) = K_C$
   2. $CO(s) / E(s) = K_C (1+ \tau_I S)$
   3. $CO (s) /E(S) = \tau_I S$
   4. $CO(s)/ E(S) = K_C + K_C / (\tau_I S)$
   5. $CO(s)/ E(S) = K_C + K_C S/ \tau_I$
9. Which is the appropriate statement for closed loop control and open loop control?
   1. The response of an open loop control occurs in the system without a recycle stream.
   2. The response of a closed loop control occurs in the system with recycle streams.
   3. The response of an open loop and a closed loop controls occur in a system with/without a recycle stream.
   4. The response of an open loop control occurs in the system with/without recycle streams but the response of the closed loop control occurs only in the system with recycle streams.
   5. No solution.
10. In order to design parameters for PID controller, what are the parameters needed to be concerned the most?
    1. Response time 2. Settling time 3. % Overshoot
    4. All are eventually important.
    5. All are important depending on the control objective and process constraints.
11. Which answer is correct for feed back control and feed forward control?
    1. Feed back control is used for the controlled variable at the process exit.
    2. Feed forward control controls manipulated at the process entrances.
    3. Do not measure the control variable for feed forward control. But for feed back control, the controlled variable need to be measured.
    4. Choices 1 and 2 are correct. 5. All are correct.

12. Which statement is correct for a ratio control?
    1. Ratio control is feed forward control.
    2. Ratio control requires to measure at lease 2 process variables except a controlled variable.
    3. Ratio control gives the exact controlled variable fast.
    4. Choices 1 and 2 are correct.
    5. All are correct.
13. Which statement is true for a cascade control?
    1. Controlled variable of one control loop is a set point of another control loop.
    2. At lease 2 control loops have the same control variable.
    3. Cascade control can be both feed back and feed forward control.
    4. Choices 2 and 3 are correct.
    5. All are correct.
14. Which a controller makes the process offset?
    1. P 2. PI 3 PID 4 PD 5. ID
15. Which one provides the oscillation in the first order process?
    1. P 2. I 3. PI 4. PD 5. Choices 2 and 3 are correct.
16. The tank pressure is controlled by adjusting the gas effluent flow rate. If the pressure was higher than the set-point, which statement is the most correct for the control valve, and controller action used in the process?
    1. Air to close valve and direct action controller.
    2. Air to open valve and direct action controller.
    3. Air to close valve and reverse action controller.
    4. Air to open valve and reverse action controller.
    5. No solution.
17. Which statement is true for gain and reset time of PI –controller in the first order system?
    1. Increasing gain and reset time increases the process oscillation.
    2. Increasing gain but decreasing reset time increases the process oscillation.
    3. Decreasing gain but increasing reset time increases the process oscillation.
    4. Decreasing gain and reset time increases the process oscillation.
    5. No conclusion.
18. Which equipment in the process control loops has the least important?
    1. Measuring devices 2. Transducer 3. Controller 4. Control Valve 5. Recorder
19. Which is not the main objective of having control system in the process?
    1. Process Safety
    2. Environment friendly
    3. Process optimization
    4. Quality and Quantity requirement
    5. Modern and creditable

20. Which one is correct for valve characteristic (f(x))?
    1. Linear valve: $f = x$, Quick opening: $f = x^{0.5}$, Equal percentage: $f = R^{x-1}$
    2. Linear valve: $f = x^2$, Quick opening: $f = x$, Equal percentage: $f = R^{x-1}$
    3. Linear valve: $f = x$, Quick opening: $f = x^2$, Equal percentage: $f = R^{x-1}$
    4. Linear valve: $f = x$, Quick opening: $f = x^{0.5}$, Equal percentage: $f = R^x$
    5. Linear valve: $f = x$, Quick opening: $f = x^2$, Equal percentage: $f = R^x$

Part II

1. (30 Points) For chemical C Production. The reaction in a reactor is: $A + 2B \Leftrightarrow C$. Chemical A is cheaper than chemical B. The process temperature, T, should be at 50 °C for the desired concentration of C. The process requires heat from a steam to maintain the reactor temperature. The reactor level is disturbed by the production rate of C and the production rate of C is desired by the customer.
    a. Declare 2 pairs of controlled and manipulated variables in feed back control loop.
        1. Controlled variable _____ Manipulated variable_____
        2. Controlled variable _____ Manipulated variable_____
    b. For ratio control, which steam should be a wide stream and why?
        Wide stream is_____because_____
        _____
    c. Draw a process control diagram (put control valves, transmitter, and controllers) with ratio, and feedback controls in the process below.

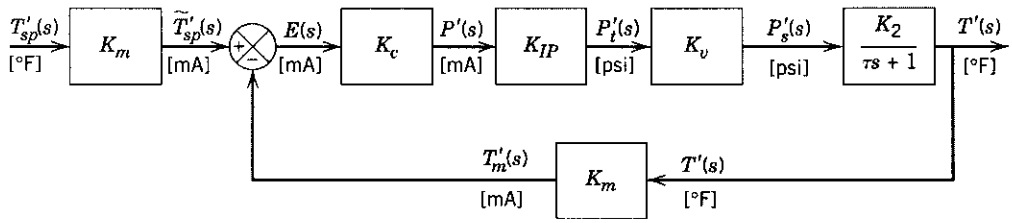


    d. If you want to improve the process, which the control structure should be used instead of using normal feedback control._____
        _____

2. (40 Points) Consider a proportional control of a stirred tank heater control system. The temperature transmitter has a span of 50 °F and a zero of 55 °F. The nominal design conditions are Tss = 80 °F. The controller has gain of 5, while the gains for the control valve and current-to-pressure transducer are Kv = 1.2 (dimensionless) and K_{IP} = 0.75 psi/A, respectively. The time constant for the tank is τ = 5 min. The control valve and transmitter dynamics are negligible. After the set point is changed from 80 to 85 °F, the tank temperature eventually reaches a new steady state value of 84.14 °F. (standard current range of 4-20 ma for transducer)

   2.1 What is the offset of the process?

   2.2 What is the process gain K_2?



3. (40 Points) A Process control system contains the following transfer function:

$Gp(s) = \frac{2e^{-1.5s}}{(25s+1)}, Gv = \frac{0.5e^{-0.3s}}{4s+1}, Gm = 3e^{-0.2s}, Gc = Kc$. The approximation for deadtime is

$e^{-s} \approx \left(\frac{1-0.5s}{1+0.5s}\right)$

3.1 Draw a control block diagram.

3.2 Show the characteristic equation.

3.3 Use Routh stability methods to find the range of Kc

3.4 Use direct substitution method to find a critical gain and a critical frequency.

4. (50 Points) If an open loop transfer function without controller is $G(s) = \frac{5}{(0.02s+1)(0.2s+1)(s+20)}$

4.1 Show the magnitude and phase angle as a function of frequency and sketch the Bode diagram of the process.

4.2 Find ultimate frequency (at phase lag -180°) and amplitude ratio.

4.3 If proportional controller is desired to use in the process, determine the value of Kc that makes the phase margin of 50 ° and gain margin of 2.