BITS, PILANI – DUBAI CAMPUS
Knowledge Village, Dubai
Year IV – Semester I 2006– 2007
COMPREHENSIVE EXAMINATION (Closed Book)

Course No : **INSTR UC451**

Course Title : **Process Control**

Date : **27.12.05**

Time : **3 Hours** **Max.Marks** : **80 (40 %)**

1. Answer all the questions.
2. If you are using graph or semi log graph sheets, first get it signed by the invigilator then only use it. **Graph sheets** used without **invigilator signature** will not be accepted.
3. All the symbols carry their usual meanings unless otherwise stated.
4. Any missing data can be assumed, but need to be mentioned.

PART - A **(2 x 10 = 20)**

I.

1. What are the fundamental dependent variables?
2. What are the types of plugs for pneumatic valves?
3. How do you design a best controller?
4. Define degree of freedom. How do you reduce DOF to zero so that you can have completely specified system with unique behavior
5. Why is the controller design of process with dead time are particularly sensitive and difficult problem. Explain.
6. Develop the state equation that will describe the dynamic behavior of general i^{th} tray of distillation column.
7. Is it advisable to use only proportional controller for pure capacitive process? Justify your answer.
8. Why the time integral criterion is not used for tuning proportional controller. Explain.
9. Non-interacting capacities always result in an over damped or critically damped second order system and never in an under damped system. Why?
10. How do you calculate the K_c, τ_I, τ_D using Ziegler& Nichols method for PID controller.?

PART - B

(6 x 10 =60)

2.Develop the mathematical model for continuous stirred tank reactor shown in figure1.

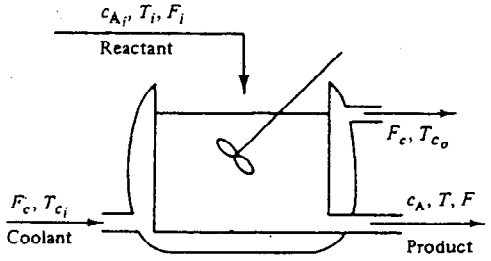

Fig (1)

3. The characteristics polynomial of a system is $s^6+s^5+3s^4+3s^3+3s^2+2s+1=0$. Use the Routh stability criterion to determine the location of roots on s – plane and hence the stability of the system.

4.The open loop transfer function of a unity feedback system is given by $G(s) = 1 / s^2(1+s)(1+2s)$. Sketch the polar plot and determine the gain margin and phase margin.

5. Sketch the Bode plot for the following transfer function and determine the gain and phase cross over frequencies. $G(s) = 10/ s(1+0.4s)(1+0.1s)$.(Assume the low frequency as 0.1rad/sec and high frequency as 50 rad/sec).

6. Sketch the Root locus for the unity feedback system whose open loop transfer function is $G(s) = K / s(s^2+6s+10)$.

7. What is Adaptive control? When we have to go for adaptive control system? Explain the types of self adaptive control.

ALL THE BEST

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TEST II (Open Book)

Course No: INSTR UC451

Course Title: Process Control

Date:17.12.06 Time: 50 Minutes M.M = 20(20%)

ONLY TEXT BOOK IS ALLOWED.

ANSWER ALL THE QUESTIONS (4*5=20)

1. Consider the block diagram of the closed loop system shown in figure 1.For a unit step change in the set point, do the following :

   (a) Compute the overshoot , decay ratio and period of oscillation when
   - **(1) $K_c = 1$; $\tau_I = 0.5$**
   - **(2) $K_c = 20$; $\tau_I = 0.5$**
   - **(3) $K_c = 1$; $\tau_I = 0.1$**

   (b) Compare the responses found in part (a) and discuss the effect of K_c and τ_I on the closed loop response of a system.

   (c) Sketch qualitatively the responses for the three cases of K_c and τ_I values given in part(a).

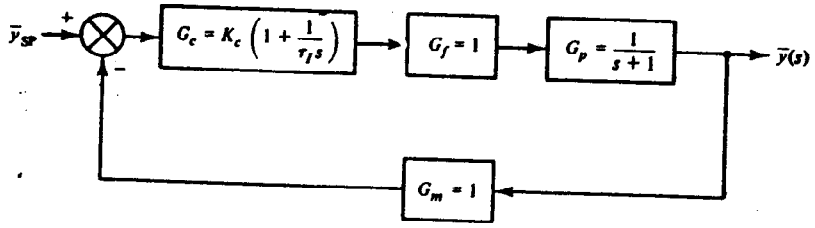

Fig (1)

2. A first order system with a transfer function $G_p(s) = 5 / 0.1s + 1$ is controlled with a feedback PI controller $G_c(s) = K_c(1+1/\tau_I s)$. Assuming that the final control element has a transfer $G_f = 1$ and that the transfer function of the measuring device is $G_m(s) = K_m/\tau_m s + 1$. Do the following,

   (a) Set $K_m = 1$, $\tau_m = 1$, and using the Routh criterion , find a pair of values K_c and τ_I which yield stable closed loop response.
   (b) Using the values of **Kc** and τ_I found in part (a), examine the effect of changing K_m on the stability of the closed loop response.
   (c) Do the same with τ_m.
   (d) Based on the results above, discuss the effect that measurement dynamics have on the stability of the closed loop response.

3. Sketch the Bode plot for the following transfer function.

   $G(s) = K e^{-0.2s} / s(s+2)(s+8)$.

   Find K so that the system is stable with
   (a) gain margin equal to 6bd
   (b) Phase margin equal to 45°.

   (Assume low frequency as 0.5rad/sec and high frequency as 50rad/sec)

4. Draw the root locus of a closed loop system with the following characteristics:

   Process: $G_p(s) = 1/(s+1)(2s+1)$

   Controller: $G_c(s) = K_c$

   Measuring Device: $G_m(s) = 1$

   Final control element: $G_f(s) = 1$

   Indicate what segments of the root locus (ie. Values of K_c) yield (a) over damped (b) Critically damped and (c) Under damped closed loop responses.

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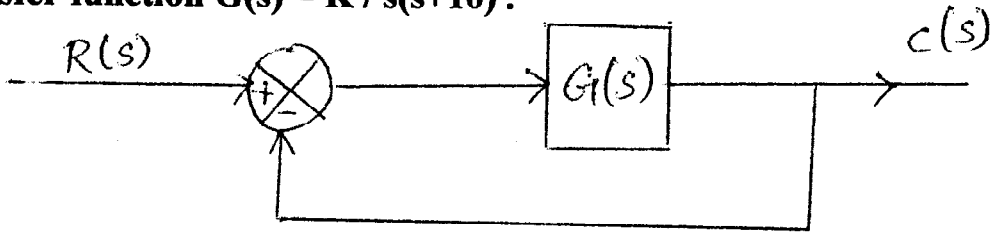
QUIZ (Closed Book)

Course No: INSTR UC451

Course Title: Process control

Date: 23.11.06 Time: 30 Minutes M.M = 10(10%)

A. The unity feedback system is characterized by an open loop transfer function G(s) = K / s(s+10) .



1. **Determine the gain K, so that the system will have a damping ratio of 0.5 for this value of K. .....**

2. **The value of W_n is .....**

3. **The value of settling time is .....**

4. **The value of peak overshoot 1s .....**

5. **The value of time to peak overshoot is .....**

6. **Non interacting capacities always results in .....damped or ..... damped system.**

7. **A First order lag process is self regulatory process.....**
(True/ False)

8. **Non minimum phase response is otherwise called as.....**

9. **Process with dead time are easy or difficult to control and Why?**

10. **The smaller the value of the time constant , the stepper the initial response of the system.....**
(True/False)

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TEST I (Closed Book)

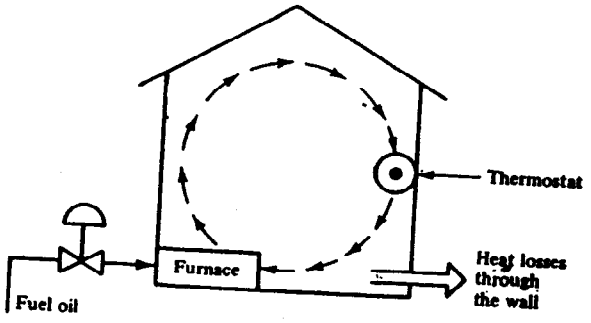
Course No: INSTR UC451

Course Title: Process Control

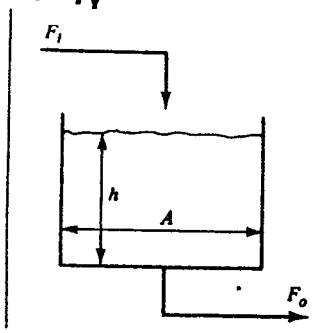
Date: 29.10.05 **Time: 50 Minutes** **M.M = 20(20%)**

ANSWER ALL THE QUESTIONS **(4*5=20)**

1. **Consider the air- heating system used to regulate the temperature in a house. The heat is supplied from the combustion of fuel oil.**
   a. **Identify the control objective, the available measurements. What are the external disturbances for such a system?**
   b. **Is this a SISO system?**
   c. **Develop a feedback control configuration to achieve your control objective.**
   d. **Is a feed forward control configuration possible for achieving your control objective? How?**



2. **Find the linearized model of the system in terms of deviation variable for the figure shown below. Assume $F_0 = \beta\sqrt{h}$**



3. **Consider a dynamic system described by two state variables x_1 and x_2 and the following state equation.**

$$dx_1 / dt = f_1(x_1, x_2, m_1, m_2, d_1)$$

$$dx_2 / dt = f_2(x_1, x_2, m_1, m_2, d_2)$$

m_1, m_2 are the manipulated variables and d_1, d_2 are the two disturbances affecting the system. Find the linearized approximation of the non linear state equation in terms of deviation variables.

4. **Find the all the Differential equations for the binary distillation column shown below.**