Code No: RR320803 **Set No. 1**

III B.Tech II Semester Supplementary Examinations,
November/December 2005
PROCESS DYNAMICS AND CONTROL
(Chemical Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. A thermometer having a first order time constant of 0.2 min is placed in a temperature bath, and after the thermometer comes to equilibrium with the bath, the temperature of the bath is increased linearly with time at a rate of 1^o/min.
   (a) What is the difference between the indicated temperature and the bath temperature for 1.0 min after the change in temperature begins?
   (b) What is the maximum deviation between the indicated temperature and the bath temperature and when does it occur?
   (c) Plot the forcing function and the response. [6+6+4]
2. (a) What is an interacting and non - interacting system? Explain with examples.
   (b) Derive an expression for the response of two non-interacting liquid - level tanks in series with equal time constants, for step change in the inlet flow rate. [8+8]
3. Define the following
   (a) Set - point
   (b) Load
   (c) Closed - loop system
   (d) Comparator [4+4+4+4]
4. (a) Develop the block diagram of a generalized feed back control system with one disturbance, incorporating in each block the appropriate transfer function and on each stream the appropriate variable. [8]
   (b) Develop the closed loop responses for set point and load changes. [4+4]
5. For the control system shown in figure1 determine
   (a) C(s)/R(s)
   (b) offset
   (c) C(0.5)
   (d) whether the closed loop response is underdamped when U = 0 [4+4+4+4]
6. Discuss the rules for plotting root - locus diagrams in detail. [16]

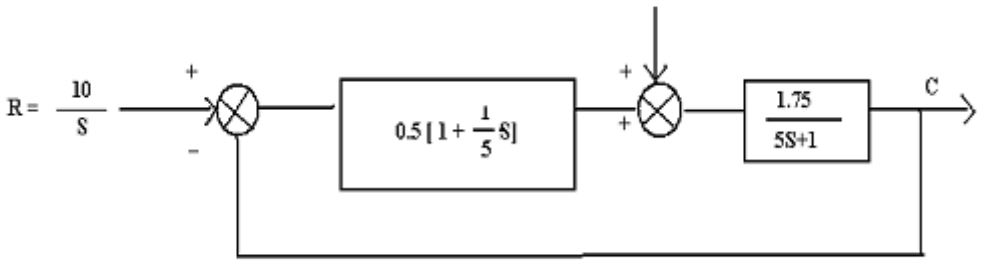

Figure 1:

7. Sketch the gain versus frequency asymptotic Bode diagram for the following transfer function. Also find the actual gain and phase angle at $\omega = 10$

$$G(s) = \frac{100}{(10s+1)(s+1)}$$

[16]

8. (a) Explain feedforward control using a neat schematic.
   (b) Present a comparative analysis of feedforward and feedback strategies [8+8]

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Code No: RR320803 **Set No. 2**

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1. (a) Write the expressions in Laplace and time domain for the sinusoidal response of a general first order system.
   (b) Find the dynamic response of a first order lag system with time constant of 0.5 and static gain of 1.0 to a sinusoidal input change, sin 0.5t. [8+8]

2. Define and discuss the following terms
   (a) Overshoot
   (b) Decay ratio
   (c) Rise time
   (d) Response time [4+4+4+4]

3. A pneumatic PI controller has an output of 10psi when the set point and pen point are together. The set point and pen point are suddenly displaced by 0.5 inches (i.e. a step change in error is introduced) and the following data are obtained:

Time	0-	0+	20	60	90
Psig	10	8	7	5	8.5

   Determine the actual gain (psig per inch displacement) and the integral time [8+8]

4. (a) Develop the block diagram of a generalized feed back control system with one disturbance, incorporating in each block the appropriate transfer function and on each stream the appropriate variable. [8]
   (b) Develop the closed loop responses for set point and load changes. [4+4]

5. (a) Using T_1 =1,T_2 =T_3 = 1/3, determine the values of Kc for which the control system shown in figure1 is stable.
   (b) For the values of Kc for which the system is on the threshold of instability, determine the roots of the characteristic equation. [8+8]

6. For the open loop transfer function of a control system shown below.

$$GH(s) = \frac{K}{s(s^2 + 2s + 2)}$$

   Draw the root locus plot. Determine the three roots of the characteristic equation, when K is taken as 4. [16]

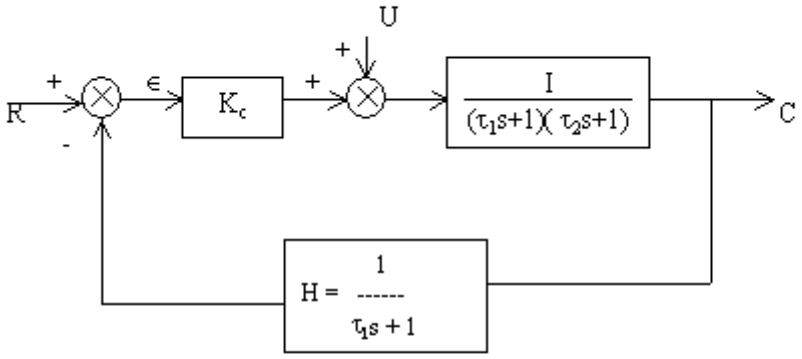

Figure 1:

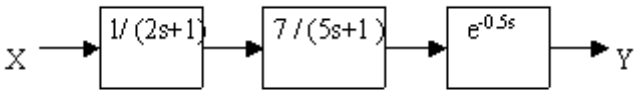

Figure 2:

7. Plot the Bode figure2 for the above process accurately and neatly using log-log paper for gain Vs frequency and semi-log paper for phase Vs frequency. Plot frequency as rad/min. [8+8]

8. (a) Explain ratio control in detail with a neat schematic diagram.
   (b) Quote some commonly encountered examples from chemical industry where ratio control can be used. [8+8]

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1. (a) How do you represent a physical system by first and second order ordinary differential equations ? Express the solution of a general first order system considering unit step input for the system.
   (b) A primary transducer is subjected to a sudden change. The time constant of the transducer is 2 seconds. How long will it take for the transducer to show half the temperature difference? [10+6]

2. Consider a second order system with the following transfer function. G(s) $=\frac{1}{s^2+s+1}$. Introduce a step change of magnitude 5 into the system and find
   (a) percent over shoot
   (b) decay ratio
   (c) maximum value of Y(t)
   (d) rise time
   (e) ultimate value of Y(t)
   (f) period of oscillation. [3+3+3+3+2+2]

3. A first order process is controlled by a PD controller. The control valve is assumed to be a first order. Assuming the measuring element is having negligible time constant. Develop a block diagram for the feedback control system and obtain an overall transfer function. [16]

4. (a) Develop the block diagram of a generalized feed back control system with one disturbance, incorporating in each block the appropriate transfer function and on each stream the appropriate variable. [8]
   (b) Develop the closed loop responses for set point and load changes. [4+4]

5. (a) Discuss the theorems of the Routh test
   (b) For characteristic equation $s^4 + 6s^3 + 11s^2 + 36s + 120 = 0$, determine the stability using Routh Criterion. [8+8]

6. Sketch the root locus for the following equation.

$$1 + \frac{K}{(s+1)(2s+1)} = 0$$

on your sketch you should locate quantitative all poles, zeros, and asymptotes. In addition show the parameter that is being varied along the locus and direct in which the loci travel as this parameter is increased [16]

7. (a) State and explain Bode stability criterion. [8]

   (b) Sketch Bode plots for the following components of a control system

   i. 1/(S+1)
   ii. 10/(S+1)
   iii. e^{-S}

   [2+3+3]

8. (a) Explain ratio control in detail with a neat schematic diagram.

   (b) Quote some commonly encountered examples from chemical industry where ratio control can be used. [8+8]

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1. (a) An isothermal CSTR irreversible reaction is described by

$$\frac{dC_A}{dt} + \left(\frac{1}{\tau} + k\right) C_A = \frac{1}{\tau} C_{Ao}$$

where k and τ are constants. C_A is the concentration of the component in the reactor and C_{Ao} is the concentration of the entering component to the reactor. Write the transfer function model for the system. What are the process time constant and process steady state gain of the model.

(b) A temperature sensing device can be modelled as a first order system with a time constant of 6 sec. A step change is introduced in the input temperature of 150^0 C to 25^0 C. Find the temperature after 10 sec. [8+8]

2. (a) Show the block diagram representation of several non interacting first order systems in series. How do you express the overall transfer function from individual transfer functions of several first order systems in series?

(b) A step change of magnitude 3 is introduced into the transfer function

$$\frac{Y(s)}{X(s)} = \frac{10}{[2s^2 + 0.3s + 0.5]}$$

Determine the overshoot and frequency of oscillation [8+8]

3. Discuss the working principle & mechanism of pneumatic PID controller with the help of a neat schematic diagram [16]

4. (a) Develop the block diagram of a generalized feed back control system with one disturbance, incorporating in each block the appropriate transfer function and on each stream the appropriate variable. [8]

(b) Develop the closed loop responses for set point and load changes. [4+4]

5. (a) Given the characteristic equation $s^4 + 3s^3 + 5s^2 + 4s + 2 = 0$, determine the stability by Routh criterion.

(b) What is the order of the closed loop dynamic response for second order process with PI control? Can PI control destabilize such a process. [8+8]

6. Discuss the rules for plotting root - locus diagrams in detail. [16]

7. The open loop transfer function of a control system is given below:

$$GH(s) = \frac{K_C(2s+1)e^{-0.25}}{s^2(0.5s+1)}$$

Draw the open loop Bode plot for the system and determine the value of K_C for a phase margin of 30^0. [16]

8. Write in detail on valve sizing and selection. [16]

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