Code No: 07A60804 **R07** **Set No. 2**

III B.Tech II Semester Examinations,December 2010
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) Explain the reasons to use a valve positioner.
   (b) What are the conditions under which equal percentage and linear valves are used. Explain.
   (c) What is meant by valve sizing? Explain. [6+6+4]
2. What is a first order system and how do you derive the transfer functions of a first - order system? Explain with an example. [16]
3. Two tanks are connected in an interacting fashion as shown below figure 1:

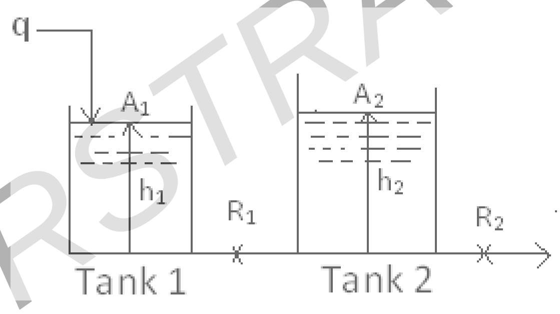

Figure 1:

The system is initially at steady state with q = 12 cfm. The following data apply to the tanks: $A_1 = 1$ ft^2 ; $A_2 = 1.5 ft^2$; $R_1 = 1 ft/cfm$; $R_2 = 0.9 ft/cfm$.

   (a) If the flow changes from 12 to 13 cfm, according to a step change, determine H_2(s), where H_2 is the deviation in h_2.
   (b) Determine $H_2(1)$, $H_2(2)$, $H_2(4)$ and $H_2(\ \mu\ )$.
   (c) Determine the initial levels $h_1(0)$, $h_2(\infty)$ in the tank. [6+4+6]
4. The block diagram of a conventional feed back control system contains the following transfer function:
$G_p = \frac{5e^{-2s}}{10s+1}$; $G_c = K_c\left(1 + \frac{1}{5s}\right)$; $G_m = \frac{1}{s+1}$; $G_v = 1$
   (a) For $K_c = 0.2$, what is the phase margin?
   (b) What value of K_c will result in a gain margin of 1.7? [16]

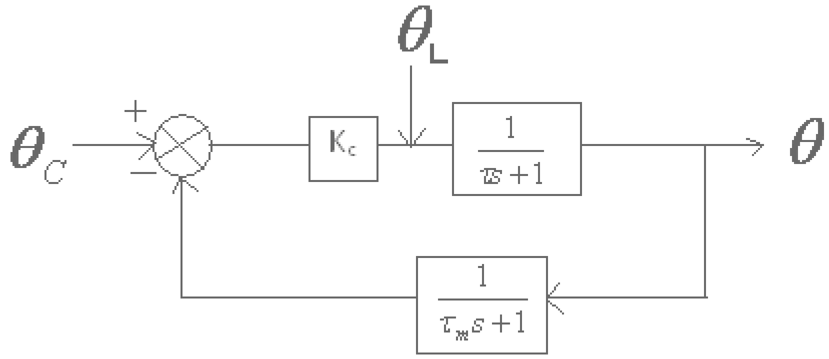

Figure 2:

5. For the following system as shown in figure 2 with a first order measurement lag, and controlled by a proportional control, derive the response for a unit step change in load. [16]

6. Explain Pneumatic control valves are to be specified for the applications listed below. Explain whether an air to open or air to close should be specified for the following manipulated variables.
   (a) Steam pressure in a reactor heating coil.
   (b) Flow rate of reactants into a polymerization tank.
   (c) Flow of effluent from a waste water treatment holding tank into a river.
   (d) Flow of cooling water to a distillation condenser. [16]

7. It is desired to control level h_2 in the storage system shown below figure 3 by manipulating flow rate q_3. Disturbance variable q_1 can be measured.
   (a) Draw a block diagram for a feed forward - feed back control system.
   (b) Derive an ideal feed forward controller

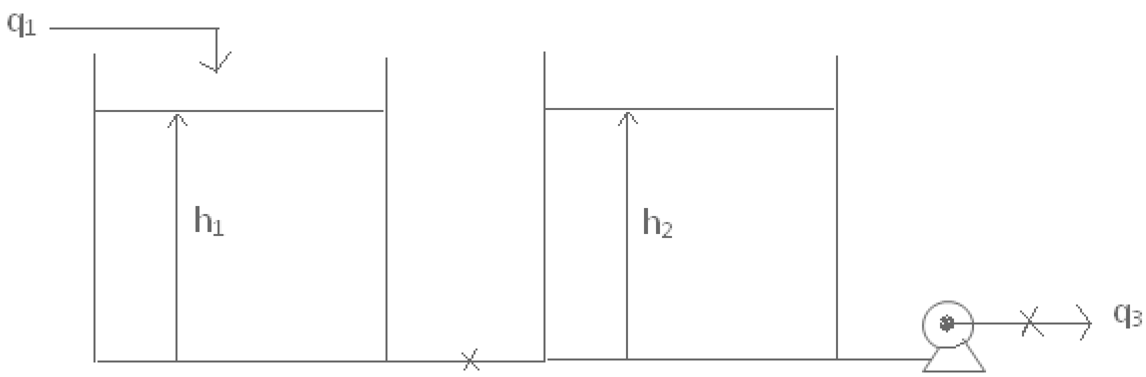

Figure 3:

Information available:

(a) Two tanks have uniform cross-sectional areas A_1 and A_2 respectively.

(b) The valve on the exit line of Tank 1 acts as a linear resistance with a flow-head relation , $q_2 = (h_1 - h_2)/R$

(c) The transmitters of control valve are pneumatic instruments that have negligible dynamics.

(d) The pump operates so that flow rate q_3 is independent of 'h_2' when the control valve stem position is maintained constant. [16]

8. Draw the root-locus diagram 4 for the following control system.

(a) Determine the value of Kc needed to obtain a root of the characteristic equation of the closed-loop response which has an imaginary part 0.75.

(b) Using the value of Kc found in part (a), determine all the other roots of the characteristic equation from the root-locus diagram. [8+8]

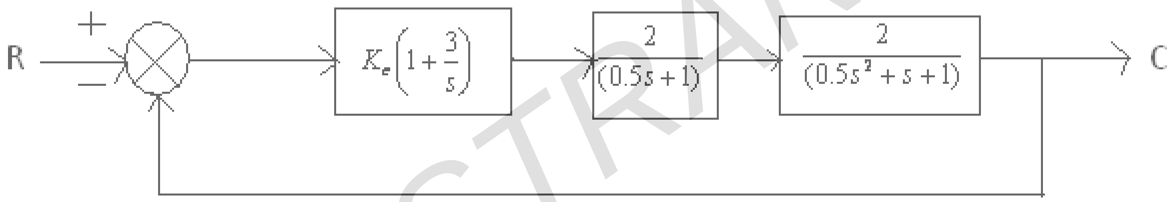

Figure 4:

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1. Sketch the root locus for the unity feed back system shown below figure 5: [16]

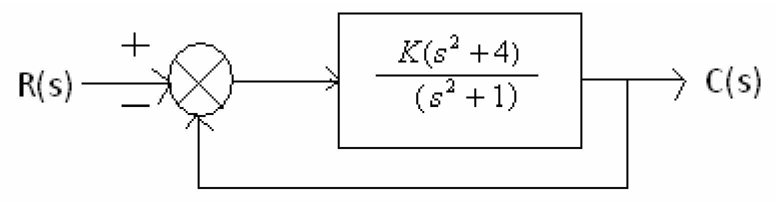

Figure 5:

2. A control system shown below figure 6contains a three-mode controller.
For $\tau_D = \tau_I$ =0.5 and τ_1 = 1,

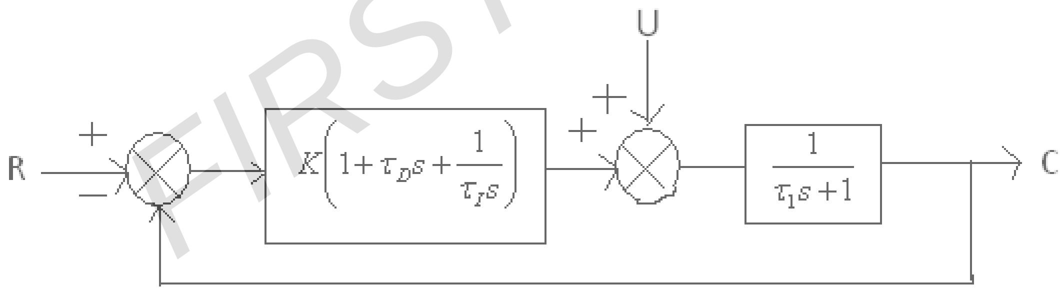

Figure 6:

(a) Determine the response C(t) for a unit step change in set point and load, if K = 1.

(b) Determine the maximum value of C and the time at which it occurs for both cases of part (a). [8+8]

3. (a) Derive the transfer function for mercury thermometer.

(b) A mercury thermometer with a time constant of 0.1 min is placed in a temperature bath at 50^0C and allowed to come to equilibrium with the bath. At time t = 0 , the temperature of the bath begins to vary sinusoidally about its average temperature 50^0C with an amplitude of 20^0C. If the frequency of oscillation is $5/\Pi$ cycles per second, obtain the equation for the response of thermometer and phase lag. [8+8]

4. (a) Explain the strategy of ratio control.
   (b) How do you propose to compensate for large dead times in process systems. [8+8]

5. (a) Using Cohen-coon method, design a PID controller for the control system with the open loop transfer function.
   $G(s) = 0.5/[(s + 1)(0.5s + 1)(2s + 1)]$
   (b) Explain the error integral criteria for tuning of feed back controller. [8+8]

6. (a) Write the ideal transfer functions of proportional, PI, PD and PID controllers. Write units of the controller parameter for a pneumatic controller.
   (b) Explain with the help of examples, how the overall transfer function of a feed back system is obtained for servo and regulatory problem. [8+8]

7. (a) Plot the asymptotic Bode diagram $7|B/\varepsilon|$ vs ω for the control system shown below:

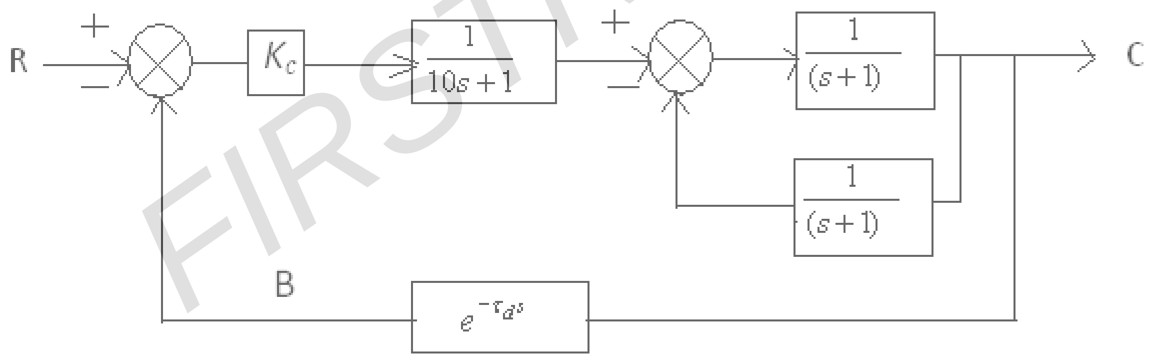

Figure 7:

   (b) The gain K_c is increased until the system oscillates continuously at a frequency of 3 rad/min. From this information, calculate the transportation lag parameter τ_d. [16]

8. A first order approximation of a mercury thermometer is to have all its resistance in the convective film surrounding the bulb and all its capacitance in the mercury. A more detailed analysis would consider, both the convective resistance surrounding the bulb and that between the bulb and mercury. In addition, the capacitance of the glass bulb would be included. Using proper notations derive the transfer function between temperature of surrounding fluid and temperature of mercury. [16]

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Code No: 07A60804 **R07** **Set No. 1**

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1. Derive the expressions for response of cascade systems to load changes. [16]

2. Discuss merits and demerits of different types of controllers. [16]

3. Discuss any three forcing functions and obtain the dynamic behavior of the processes. Explain them graphically and mathematically. [16]

4. (a) Explain the concept of root locus. Give the procedure for plotting the root locus diagram along with the rules proposed by Evans. Consider the following open loop transfer function as an example.
$G = \frac{K}{(s+1)(s+2)(s+3)}$.
   (b) Discuss the limitations of Routh test. [10+6]

5. (a) Sketch the open-loop Bode diagram for $K_c = 2$ and $\tau_D = 1$. For the upper part of the diagram 8(AR versus ω), show the asymptotic approximations. Include in the open-loop Bode diagram, the transfer function for the controller.

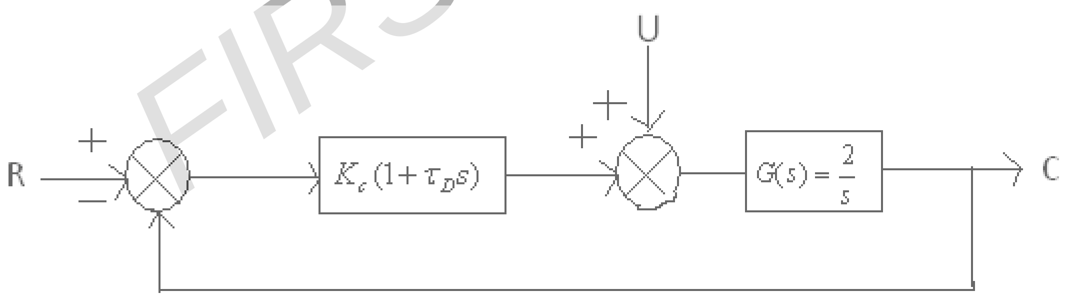

Figure 8:

   (b) From the Bode diagram, conclude the stability of the closed loop system. [10+6]

6. (a) Explain why two interacting first order systems have more sluggish response than two equivalent but non-interacting systems.
   (b) Sketch qualitatively, the response of systems with the following transfer function
$G(s) = \frac{s+1}{(s+2)(s+3)}$. [8+8]

7. For the control system shown below figure 9, determine the controller settings using Ziegler-Nichols method. [16]

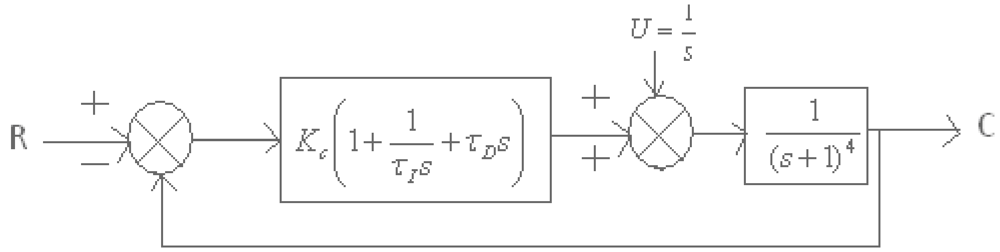

Figure 9:

8. The block diagram 10 of a special feed back control system is shown below. Derive an expression for the closed loop transfer functions Y(s)/D(s) and Y(s)/Ysp(s). [16]

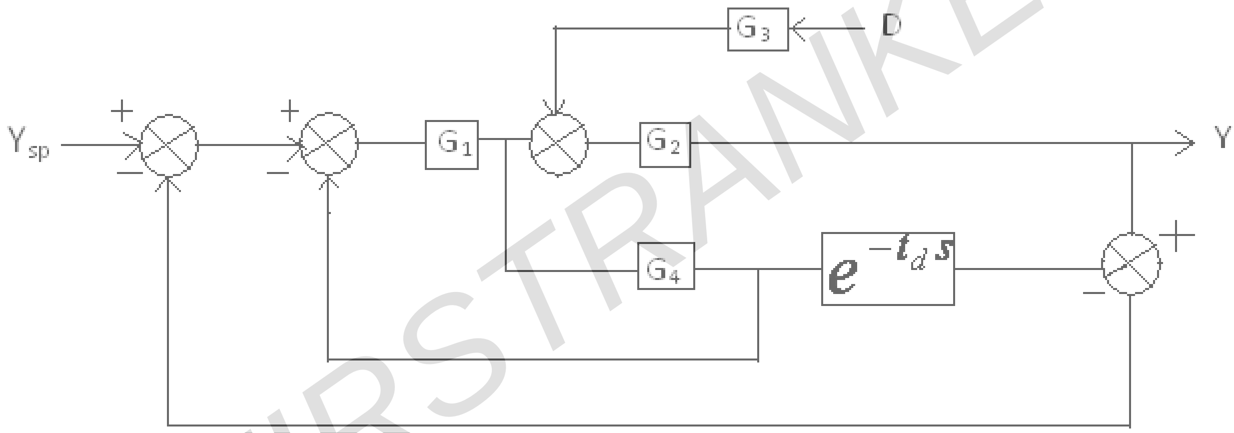

Figure 10:

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Time: 3 hours Max Marks: 80

Answer any FIVE Questions
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1. Discuss the method of linearization. [16]

2. Sketch the root locus for the unity feed back system shown below figure 11: [16]

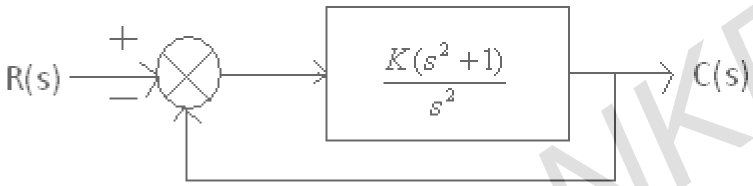

Figure 11:

3. Giving examples, explain the purpose of ratio control. [16]

4. (a) Determine the factors to be taken into account for using air-to-open or air-to-close pneumatic control valves.

   (b) A pneumatic controller has an output pressure of 10 psi when the set point and pen point are together. The set point and pen point are suddenly displaced by 0.5 in (i.e., a step change in error is introduced) and the following data are obtained. [16]

Time (sec)	0	0+	20	60	90
psig	10	8	7	5	3.5

5. What is process identification? Using semi-log graphical method, determine the process model for the following unit-step response data. [16]

Time (t)	0	0.2	0.5	0.75	1	1.5	2	2.5	3	4	α
Response (y)	0	0.75	0.25	0.35	0.5	0.65	0.8	0.9	0.95	0.98	1

6. A first-order process with a dead-time has a transfer function:
   $G(s) = \frac{5e^{-.t_d s}}{0.2s+1}$.
   The process is to be controlled with a PI controller. Use the Bode stability criterion to find the range of values for the gain K_c as a function of t_d, so that the closed-loop response is stable. Take $\tau_I = 0.5$ min. [16]

7. The dynamic behavior of a packed-bed reactor can be approximated by a transfer function model.
   $\frac{T(s)}{T_i(s)} = \frac{3(2-s)}{(10s+1)(5s+1)}$

Where T_i = inlet temperature and T= outlet temperature (in ^{0}C) and time constants are in hours.
The inlet temperature varies in a cyclic fashion due to changes in ambient temperature from day to day. Here Ti varies sinusoidally with a period of 24 hours and amplitude of 12 ^{0}C. What is the maximum variation in outlet temperature? [16]

8. A closed loop system has time constants of 1 min and 10 min and a proportional controller. Obtain the response to a ramp change in set point at a controller gain that gives a damping coefficient of 0.3. Would a higher or lower gain be advantageous? Discuss. [16]

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