BITS PILANI , DUBAI CAMPUS
Dubai International Academic City, Dubai, UAE
Semester II 2011 2012
COMPREHENSIVE EXAMINATION (Closed Book)
BE (Hons) IV year EIE

Course No : INSTR C451
Course Title : PROCESS CONTROL
Date : 12.06.12 Time: 3Hours M.M = 80 (40%)

NOTE: 1. All the symbols and words carry their usual meanings, unless otherwise stated.
2. Total No of Pages.2, No of Questions. 8
3. Answer all the questions sequentially

1. Consider a process model which has the open loop transfer function with a unity feed back system

$$G(s) = \frac{K}{s(1+0.5s)(1+5s)}.$$

Sketch the polar plot in graph sheet and determine the phase margin & gain margin.
(Assume the frequencies as 0, 0.2, 0.4, 0.6, 0.8, 1.0, 2.0, 10 rad/sec) **[10M]**

2. Draw the Bode plot (in the graph sheet) for the open loop transfer function with the following dynamic components:

$$G_p(s) = \frac{100}{s(1+0.2s)(1+0.02s)}; \quad G_f(s) = 1$$

and determine (1) gain cross over frequency (2) phase cross over frequency (3) Phase Margin (4) Gain margin. (Assume Lower frequency = 0.1 rad/ sec; Higher frequency = 100 rad/sec) **[10M]**

3. The open loop transfer function of a unity feedback system is given by $G(s) = \frac{K}{s(s+1)}$

For a particular value of K, the peak overshoot is 50%.
By how much value of K be increased so as to reduce the peak overshoot by half? **[10M]**

4. 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 K_c 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. **[10M]**

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

Process: $G_p(s) = \frac{K(s+1)}{s^2(s+5)}$.

Final control element: $G_f(s) = 1$ **[10M]**

6. Consider the tanks shown in Figure 1.Find the over all transfer function for a unit step input. **[10M]**

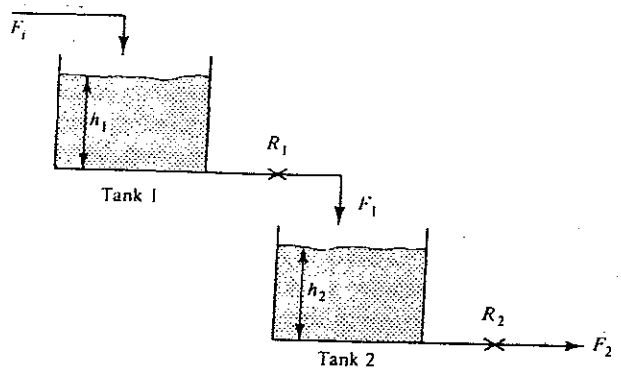

FIGURE 1

7A. For the Figure 2, find the transfer function of the process in terms of deviation variable. And also identify the order of the given process.

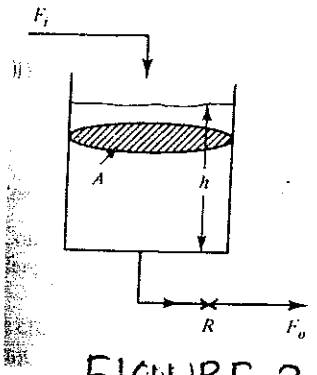

FIGURE 2

7B. What is the response of a pure capacitive process for the unit ramp input? **[7+3 M]**

8A. Find the gain of the proportional controller that produces a closed loop response f r second order with decay ratio equal to ¼. The process is described by

$G_p(s) = \frac{1}{(s^2+3s+1)}$; $G_c = K_c$ and $G_m = G_f = 1$

8B. Mention the advantage and disadvantage of proportional controller. **[7+3 M]**

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BITS PILANI, DUBAI CAMPUS
Dubai International Academic City, Dubai, UAE
Semester I 2011-2012
TEST II / (Open Book)
BE (Hons) IV year EIE

Course No : INSTR C451
Course Title : PROCESS CONTROL
Date : 13.05.2012 **Time: 50 Minutes** **M.M = 20 (20%)**

NOTE: 1. All the symbols and words carry their usual meanings, unless otherwise stated.
2. Answer all the questions.

1. Write the balancing equations and state variables for the system shown in Figure 1. All the flow rates are volumetric and the cross sectional areas of the three tanks are A_1, A_2 and A_3 (ft^2) respectively. The flow rate F_5 is constant and doesn't depend on h_3, while all other effluent flow rates are proportional to the corresponding hydrostatic liquid pressures that cause the flow. [3M]

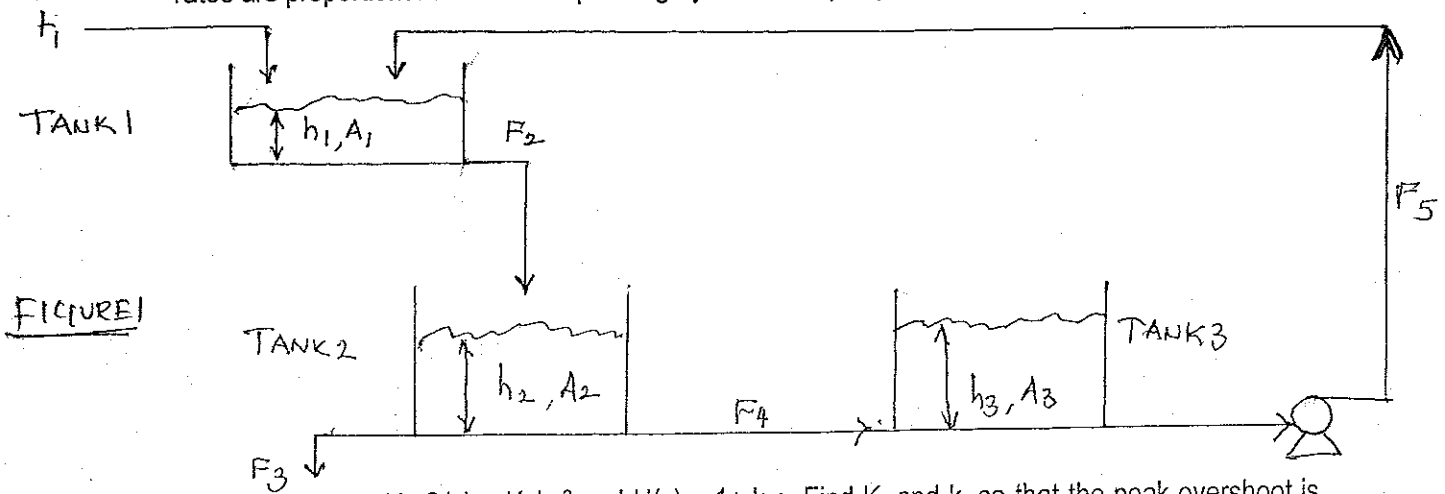

FIGURE 1

2. For a system with $G(s) = K_1/ s^2$ and $H(s) = 1+ k_2s$. Find K_1 and k_2 so that the peak overshoot is 0.25 and peak time is 2 secs when step input is applied. [6M]

3. The forward path transfer function of a unity feedback control system is given by $G(s)=\left(100 + \frac{K}{s}\right)\left(\frac{1}{4s^2+2s}\right)$. Determine the range of value of K for which the system will remain stable. [4M]

4. Sketch the root locus for the open loop transfer function of unity feedback system [7M]

$$G(s)\,H(s) = \frac{K}{s(s + 3)(s^2 + 2s + 2)}$$

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Dubai International Academic City, Dubai, UAE
Semester I 2011-2012
TEST I / (Closed Book)
BE (Hons) IV year EIE

Course No : INSTR C451
Course Title : PROCESS CONTROL
Date : 04.04.2012 Time: 50 Minutes M.M = 25 (25%)

NOTE: 1. All the symbols and words carry their usual meanings, unless otherwise stated.
2. Answer all the questions.

1. Find the total no of variables, total no of equations & the degrees of freedom for the binary distillation column shown in Figure 1. [8M]

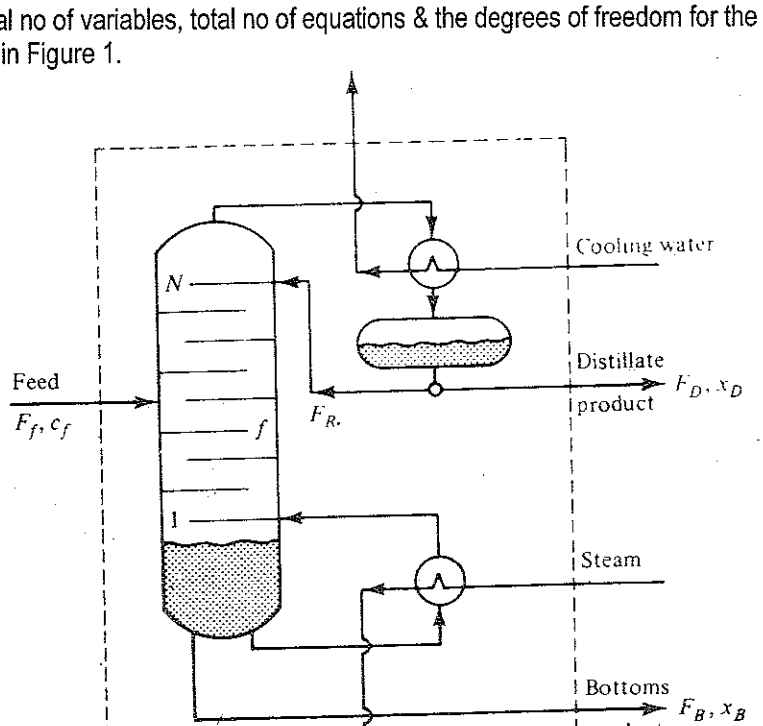

FIGURE 1

2. Figure 2 shows a system of two tanks which are used for the temporary (tank 1) and longer term (tank 2) storage of a liquid chemical product. The demand is satisfied from the temporary storage tank, while tank 2 is used to accumulate the liquid product in excess of the demand. [9M]

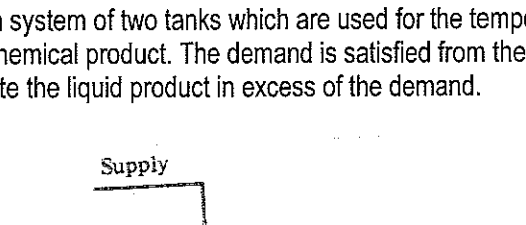

FIGURE 2

a. Identify the external disturbances
b. Identify the control objectives
c. Identify all the available measurements.
d. Identify all the manipulated variables.
e. Is this a SISO or a MIMO system?
f. Develop alternative feedback control configuration to achieve your control objective.
g. Develop alternative feedback and feed forward control configuration to achieve your control objective.
h. Is there any situation that may arise during which you cannot avoid overflowing of the storage tanks? Explain.

3. Consider the two systems shown in Figure 3. System 1 differs from system 2 by the fact that the level of liquid in the tank 2 does not affect the effluent flow rate from tank 1, which is the case for system 2.

(a) Develop the mathematical model for each of the two systems.

(b) What are the state variables for each system, and what type of balance equations have you used?

(c) Which mathematical model is easier to solve, that for system 1 or that for system 2?. Why?

Assume that the flow rate of an effluent stream from a tank is proportional to the hydrostatic liquid pressure that causes the flow of liquid. The cross sectional area of tank 1 is A_1 (ft^2) and tank 2 is A_2 (ft^2) (for both the systems). The flow rates F_1, F_2 and F_3 are in ft^3/min. [8M]

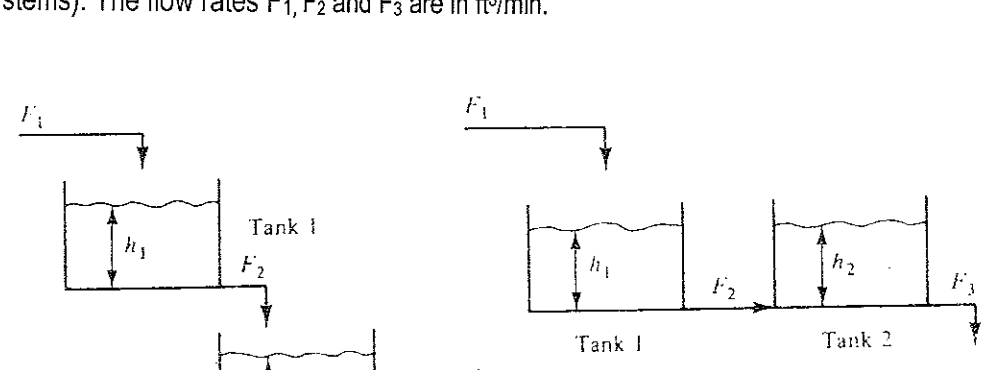

FIGURE 3

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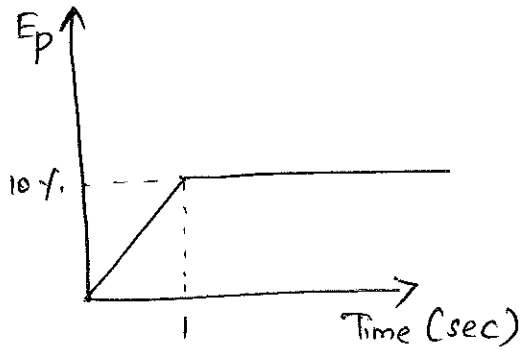
Dubai International Academic City, Dubai, UAE
Semester II 2011-2012
QUIZ II / (Closed Book)
BE (Hons) IV year EIE

Course No : INSTR C451
Course Title : PROCESS CONTROL
Date : 23.05.2012 Time: 20 Minutes M.M = 14 (7%)

NOTE: 1. All the symbols and words carry their usual meanings, unless otherwise stated.
2. Answer all the questions.

1. For unity K_p, draw the P controller response to the error curve shown in Fig 1. Assume controller output with no error is 50%. [3M]



2. In beta – gamma controller how the derivative kicks are eliminated?[1M]

3. Draw the response of P, PI & PID controllers for step input. [3M]

4. What is the difference between the servo operation and regulator operation? [2M]

5. A process control loop has G_c as PI controller. Process is an integrating element with a process gain of K. Control valve and measuring element have unity transfer function. Find the relationship among K, K_p and K_i for a damping of 0.5. [5M]

Name: ID No:

BITS, PILANI – DUBAI
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Semester II 2011-2012
QUIZ I / (Closed Book)
BE (Hons) IV year EIE

Course No : INSTR C451
Course Title : PROCESS CONTROL
Date : 05.03.2012 Time: 20 Minutes M.M = 16 (8%)

NOTE: 1. All the symbols and words carry their usual meanings, unless otherwise stated.
2. Answer all the questions.

1. Consider the air heating system used to regulate the temperature in a house (Fig 1). The heat is supplied from the combustion of fuel oil. [8 M]

(a) Identify the control objective.
(b) Identify the available measurements.
(c) Identify the external disturbances.
(d) Is this a SISO system?
(e) Develop a feed back control configuration to achieve your control objective.
(f) Is feed forward control configuration possible for achieving your control objective?

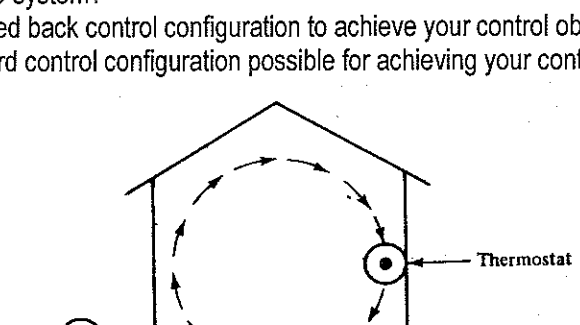

Fig 1

2. Two liquid streams with flow rates F1 and F2 and temperatures T1 and T2 flow through two separate pipes which converge at a mixing junction as shown in Fig 2. We want to maintain the constant flow rate F3 and the temperature T3 of the liquid stream resulting from the mixing of the first two streams.

Identify; [8 M]

(a) What are the control objectives?

(b) What are the manipulation variables?

(c) Develop a control system that uses only feedback controllers.

(d) Develop a control system that uses only feed forward controllers.

(e)Develop the control systems that use both feedback and feed forward controllers

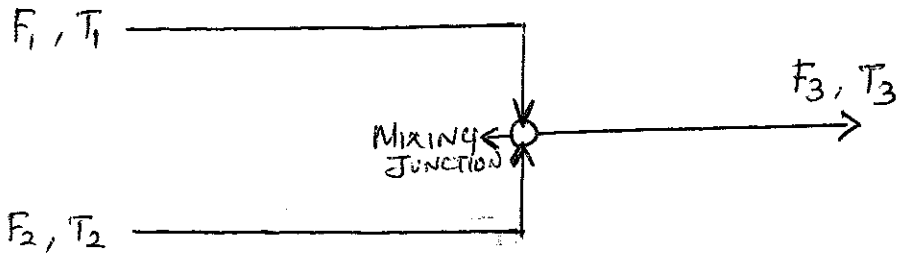

Fig 2

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