# BITS-Pilani Dubai, International Academic City, Dubai

Evaluation Component : **TEST-I (Closed Book)**

INSTR
[redacted] UC 451 PROCESS CONTROL

**Date : 11th Nov. 2007** **Max. Marks: 25**
**Duration: 50 mts** **Weightage: 25%**

Note:- 1. ANSWER ALL QUESTIONS
2. Make assumptions, if any, but explicitly indicate the assumptions made

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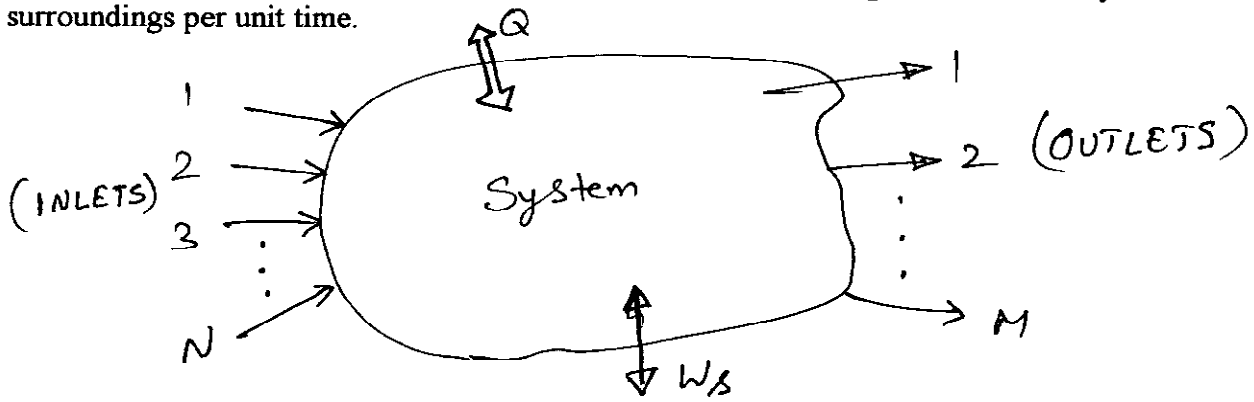
1)
a) List any FIVE requirements imposed by Engineers that a typical Chemical Process Plant must satisfy during its operation and explain about any one of them in brief (1.5 M)
b) What are the needs and incentives of Process control (1.0 M)
c) Explain how the performance of a chemical process can be optimized in a batch reactor with two consecutive chemical reactions (2.5 M)

2)
a) List any six hardware elements that are typically involved in a chemical process control system (1.5 M)
b) When is an inferential control configuration needed? What is its primary weakness? Compare it to a simple feedback control configuration. When is the one preferable over other? (3.5 M)

3)
a) Prove that a stirred tank heater system is self regulating, if the flow rate F of the effluent is proportional to the square root of the liquid level, h. (3.0 M)
b) Compare and contrast experimental and theoretical approaches of modeling a chemical process (2.0 M)

4) Obtain mathematical model of a generalized chemical process (depicted in figure below) and its interactions with external world. In the figure below: $W_s$ is shaft work engaged between the system and its surroundings per unit time; Q is the amount of heat exchanged between the system and its surroundings per unit time.




5)
a) Obtain a mathematical model of a CSTR from fundamentals. Identify the order of the system and comment on the dynamic behavior of the same. (4.0 M)
b) Why one cannot design a control system for a over-specified process? (1.0M)

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# BITS, PILANI-DUBAI

**International Academic City, Dubai**

Academic Year 2007-2008, I-Semester

IV B.E.(Hons.) E.I.E.

Elective Course: INSTR UC451 PROCESS CONTROL

Evaluation Component: TEST-II (Open Book)

Date : 16th Dec. 2007 Max. Marks : 20

Test Duration : 50 minutes Weightage : 20%

Note: 1. Answer ALL Questions
2. Make your assumptions, if any, explicit.

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Consider a generalized closed loop system with $G_p$, $G_d$, $G_c$ and $G_f$ representing the transfer functions between the corresponding inputs and outputs of the process, disturbance / load, controller and final control element respectively.

1) If $G_m$=$G_f$=1 and the process represented by: $Gp = \frac{10}{2s-1}$ is feedback controlled with a proportional controller, find the range of values of the proportional gain $K_c$ that produce stable (if it is possible) closed loop-responses. Also identify the characteristic equations. (5 M)

2) A first order process with a transfer function $G_p(s) = \frac{5}{0.1s+1}$ is controlled with a feedback PI controller $G_c(s)= K_c\left(1+\frac{1}{\tau_I s}\right)$. Assuming that the final control element has the transfer function $G_f$=1 and that the transfer function of the measuring device is $G_m(s) = \frac{K_m}{\tau_m s+1}$, by setting $K_m$=1, $\tau_m$=1 and using Routh-Hurwitz criterion, find a pair of values $K_c$ and $\tau_I$ which yield stable closed-loop response. (5 M)

3) Compare and Contrast the features of process reaction curve method of tuning controller settings with those of either Cohen-Coon method or Zielger-Nichols method (5 M)

4) Draw the root locus of a closed-loop system with the following characteristics: $G_p(s)=\frac{1}{(s+1)(2s+1)}$; $G_c(s)=K_c$; $G_m(s)=1$; and $G_f(s)=1$. Indicate what segments of the root locus (i.e., values of $K_c$) yield (a) over-damped (b) critically damped and (c) under damped closed-loop responses?

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# BITS-Pilani Dubai, International Academic City, Dubai

Evaluation Component : **Comprehensive Examination (Closed Book)**

**IV B.E.(Hons.) EIE; I semester - Academic Year 2007-2008**
**|INSTR UC451 PROCESS CONTROL**

**Date : 3rd January 2008** **Max. Marks: 80**
**Duration: Three Hours** **Weightage: 40%**

Note:- 1. ANSWER ALL QUESTIONS
2. Make assumptions, if any, but explicitly indicate the assumptions made

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1)

a) List all the five needs and three major incentives for chemical process control (4 M)

b) While considering various aspects of designing a process control system, indicate a typical but complete classification of all the variables in a chemical process. (3 M)

2)

a) In designing a control system for a chemical process list five most important design steps that one need to follow. (3 M)

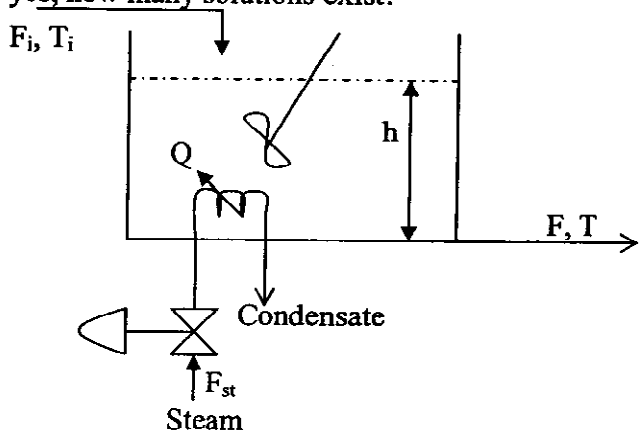
b) List the typical hardware elements that are employed while realizing a process control system irrespective of the choice of control configuration (3 M)

c) Compare and contrast experimental and theoretical approaches of modeling a chemical process (2 M)

3)

a) Categorize & List the difficulties encountered during the mathematical modeling of a typical chemical process (2 M)

b) Starting from fundamentals obtain mathematical model of a stirred tank heater shown in figure below. Further, with suitable justification(s), explain (i) whether solution of these model equations exist? (ii)If yes, how many solutions exist? (5+1+2 M)




4)

a) Offer an example, in detail, to demonstrate simplification of the model of a chemical process by both (i) how the expected impact of the disturbances and (ii) the specification of more control objectives. (4+4 M)

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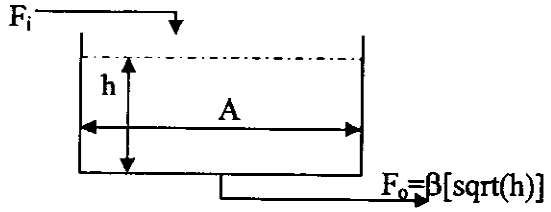
b) What is linearization? Develop a linearized approximation for the nonlinear model described by $A\frac{dh}{dt}+\beta\sqrt{h}=F_i$ of the tank system shown below. Also plot the approx. responses both before and after effecting approximation. (2+5 M)




5)

a) Starting from fundamentals of a PI controller, derive an expression and demonstrate its response to a step change in the error input, by arriving at a suitable plot of the response. (5 M)

b) A process with a transfer function $G_p(s) = \frac{10}{2s^2+3s-4}$ is controlled with a feedback PI controller $G_c(s)= K_c\left(1+\frac{1}{\tau_I s}\right)$. Assuming that the final control element has the transfer function $G_f=1$ and that the transfer function of the measuring device is $G_m(s) = \frac{K_m}{\tau_m s+1}$, by setting $K_m=1$, $\tau_m=1$ and using Routh-Hurwitz criterion, find a pair of values $K_c$ and $\tau_I$ which yield stable closed-loop response. (5 M)

6)

a) Compare and Contrast the features of process reaction curve method of tuning controller settings with those of either Cohen-Coon method or Zielger-Nichols method (5 M)

b) Draw the root locus of a closed-loop system with the following characteristics: $G_p(s)=\frac{1}{(s+1)(2s+1)}$; $G_c(s)=K_c$; $G_m(s)=1$; and $G_f(s)=1$. Indicate what segments of the root locus (i.e., values of $K_c$) yield (a) over-damped (b) critically damped and (c) under damped closed-loop responses? (5 M)

7) Write Short Notes on: (4x5=20 M)

a) The needs and incentives for Chemical Process Control
b) Use of Digital Computers in Process Control
c) Types of Pneumatic valves and their Flow capacity characteristics
d) Ratio control system or adaptive control system

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