Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/M.TECH(CHE)/SEM-1/CHE-02/2011-12

2011

ADVANCED PROCESS CONTROL

Time Allotted : 3 Hours *Full Marks* : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

Semi-log graph sheet(s) will be supplied by the Institution.

Answer any *five* questions taking at least *one* from each Group.

GROUP – A

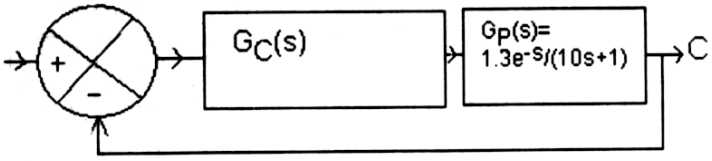
1. a) What do you mean by state space variables ?
   b) What is transfer function ? Discuss the properties of transfer function.
   c) With the help of an example draw a comparison between state space representation and transfer function representation of a physical system. 3 + 4 + 7
2. a) What do you mean by aliasing in case of digital control ?
   b) State the difference between analog and digital filters.
   c) Define *Z*-transform. Derive the expression for *Z*-transform of e^{-at}.
   d) Calculate the response of a 1st order difference equation $y(k)+a_1 y(k-1)=b_1 u(k-1)$ for $a_1 = -0\cdot368$, $b_1 = 1\cdot264$ and $y(0)=0$ using *Z*-transformation and long division for k = 0, 1, ..., 5. 2 + 3 + 4 + 5

GROUP – B

3. a) What do you mean by frequency response analysis ?

   b) What is process reaction curve ? Discuss the philosophy of the methodology that leads to Cohen-Coon setting for feedback controllers.

   c) A closed loop process has been shown in the following figure in block diagram form. Time constants and dead time values are in minutes. At the frequencies $\omega = 1{\cdot}6$ and $1{\cdot}7$ rads/min, the values of phase difference are $\phi = -178{\cdot}1°$; $-184°$ respectively. Assuming that ω versus ϕ has a linear relation in the above range of frequencies, find *ku*, *Pu*, Gain Margin, Phase Margin.



3 + 6 + 5

4. a) The overall transfer function of a control loop is

$$G_{FP}(s) = G_C(s)\,G_V(s)\,G_P(s) = \frac{k_C k_P\,(\tau_Z s + 1)\,e^{-\tau_D s}}{(\tau_{P1} s + 1)(\tau_{P2} s + 1)(\tau_{P3} + 1)}.$$

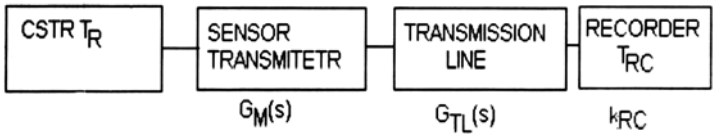
The transfer function (TF) parameters have the following numerical values :

$k_C k_P = 2{\cdot}5$, $\tau_Z = 2{\cdot}0$, $\tau_D = 0{\cdot}2$, $\tau_{P1} = 1{\cdot}0$, $\tau_{P2} = 5$, $\tau_{P3} = 10$,

[ω = 0·01; 0·025; 0·06; 0·08; 0·1; 0·2; 0·3; 0·4; 0·6; 0·8; 1·0; 2·0; 3·5; 7·0; 10·0]

All time constants are in mins. Draw a Bode plot for the above TF using following frequency values in rads/min on a suitably marked semi-log graph.

b) The temperature T_R of a CSTR is measured with a pressure bulb sensor ($\tau_M = 3s$) and a pneumatic transmission of the output signal (3-15 psig) over a long distance to a recorder. Sensor transmitter has a 1st order dynamics ($\tau_{TL} = 10s$). The recorder is calibrated in temperature units in °C, and it has no dynamic lag, so may be treated as a pure gain element. The recorder output is observed to oscillate sinusoidal between 180°C and 184°C with a time period of 31·4s. Find $T_R(t)$.



8 + 6

GROUP – C

5. a) Explain the terms "Programmed adoptive control" and "Self adoptive control". Cite example in each case.

   b) Discuss the logic of an inferential control scheme. Why is this control scheme needed ?

   c) Explain "Split range control". 5 + 5 + 4

6. a) Discuss the strategies for reducing control loop interactions.

   b) Define two open loop gains used in the definition of relating gain λ_{12}. Discuss any one way of computing λ_{12}.

c) What is meant by decoupling of two control loops ? What is one way decoupling of two control loops ?

4 + 5 + 5

GROUP – D

7. a) Discuss the procedure for the design of plant wide control system.

b) Discuss how poor process designs lead to control problems in case of a reboiler.

c) What do you mean by safe operating of a plant ?

5 + 5 + 4

8. a) Discuss the components of a DDC loop.

b) What do you mean by the response of discrete dynamic systems ?

c) Derive the discrete transfer function for the parallel form of PID controller

$$G_C(s) = k_c\left(1 + \frac{1}{\tau_1 s} + \tau_D s\right)$$

using backward difference substitution of *s*. 4 + 3 + 7

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