Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.Tech (ECE)/SEM-8/EC-803E/2013

2013
MODERN CONTROL SYSTEM

Time Allotted : 3 Hours *Full Marks :* 70

The figures in the margin indicate full marks.

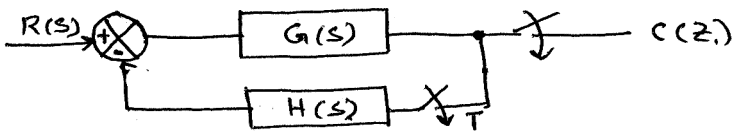
Candidates are required to give their answers in their own words as far as practicable.

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following : $10 \times 1 = 10$

i) The block diagram of a sampled data system is shown below



The output $c(z)$ of the system is given by

a) $\dfrac{GR(z)}{1 + GH(z)}$ b) $\dfrac{G(z)\,R(z)}{1 + G(z)\,R(z)}$

c) $\dfrac{G\,R(z)}{1 + G(z)\,H(z)}$ d) $\dfrac{G(z)\,R(z)}{1 + G(z)\,R(z)}$.

ii) Consider the following statements about hold circuits for reconstruction of sampled signals :

I. Hold circuits are essentially low-pass filters.

II. A first order hold circuit introduces less phase lag in comparison to a zero hold circuit.

III. A zero order hold has a flat gain frequency response over the frequency range of $0 \le w \le \frac{2\pi}{T}$ where T is the sampling period.

Which of the following statements is/are correct :

a) III alone b) I & II

c) II & III d) I alone.

iii) A Gaussian membership function can be specified as

a) Gaussian (x; c, a) = $e^{-\frac{1}{2}\left(\frac{x-c}{a}\right)^2}$

b) Gaussian (x; c, a) = $e^{\frac{1}{2}\left(\frac{x-c}{a}\right)^2}$

c) Gaussian (x; c, a) = $e\left(\frac{x-c}{a}\right)^2$

d) Gaussian (x; c, a) = $e^{-\frac{1}{2}\left(\frac{x-c}{a}\right)}$.

iv) $\int_0^T t\, e^2(t)\, dt$, where $e(t)$ is the error, is termed as

a) ITAE b) ITSE

c) ISE d) IAE.

v) The standard formula for the performance index $J = \frac{1}{2} e^T(t_1) H e(t_1) + \frac{1}{2} \int_{t_0}^{t} \left[e^T(t) Q e(t) + u^T(t) R u(t) \right] dt$ where $e(t) = [x(t) - r(t)]$ is for which of the following problems of optimal control system ?

a) State regulator problem

b) Output regulator problem

c) Tracking problem

d) Servo mechanism problem.

vi) If the z transform of a function is $\frac{z \sin wT}{z^2 - 2z \cos wT + 1}$, its corresponding Laplace transform will be

a) $\frac{s}{s^2 + w^2}$ b) $\frac{w}{s^2 + w^2}$

c) $\frac{w}{s^2 - w^2}$ d) $\frac{s}{s^2 - w^2}$.

vii) A fuzzy logic control system is

a) model based system

b) non-linguistic variable based system

c) knowledge based system

d) data based system.

viii) The order of the difference equation $y(k+2) = bx(k-1) + c\,y(k)$ is

a) 1 b) 2

c) 3 d) 4.

ix) The final value of function $F(z) = \frac{z+1}{z(z-1)}$ is

a) 1 b) 2

c) 0 d) ∞.

x) The direct method of Liapunov is based on the concept of

a) energy

b) roots of characteristic equation

c) gain margin & phase margin

d) nature of limit cycles.

xi) A two dimensional relation is expressed as $R = \{(x, y)\} | Y \geq 5x, x \in X, y \in Y\}$. This relation can be expressed as membership function by

a) $\mu_R(x, y) = \begin{cases} 1 & Y \geq 5x \\ 0 & y < 5x \end{cases}$

b) $\mu_R(x, y) = \begin{cases} 0 & Y \geq 5x \\ 1 & y < 5x \end{cases}$

c) $\mu_R(x, y) = \begin{cases} 1 & Y > 5x \\ 0 & Y \leq 5x \end{cases}$

d) $\mu_R(x, y) = \begin{cases} 1 & Y \geq 5x \\ 0 & Y \leq 5x \end{cases}$.

xii) Consider the fuzzy set $\underset{\sim}{A}$ & $\underset{\sim}{B}$ in the universe X. The complement $\underset{\sim}{\overline{A}}$ of fuzzy set $\underset{\sim}{A}$ is defined for all $x \in X$ by the equation

a) $\mu_{\underset{\sim}{\overline{A}}}(x) = 1 - \mu_{\underset{\sim}{A}}(x)$

b) $\mu_{\underset{\sim}{\overline{A}}}(x) = \min\left[\mu_{\underset{\sim}{A}}(x)\right]$

c) $\mu_{\underset{\sim}{\overline{A}}}(x) = \max\left[\mu_{\underset{\sim}{A}}(x)\right]$

d) $\mu_{\underset{\sim}{\overline{A}}}(x) = 1 + \mu_{\underset{\sim}{A}}(x)$.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. 3 × 5 = 15

2. Determine the stability of the origin of the following system :

$\dot{x} = x_2$

$\dot{x}_2 = - x_1 - x_2$ using the Liapunov's method.

3. a) What do you mean by causal signal ?

b) Define the condition of the stability of a discrete-time system. 2 + 3

4. Explain Pontryagin's minimum principle.

5. Draw block diagram of a fuzzy logic controller & explain the function of different blocks.

6. Draw a diagram to represent the membership of water temperature as per the following logic :

hot = water temperature > 60° C

warm = water temperature < 40° C

water temperature range = 30° C to 80° C.

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

7. a) State & explain Liapunov stability theorems.

b) Consider the dynamics of the system represented by

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -1 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

Determine the asymptotic stability by using the Liapunov's second method. 8 + 7

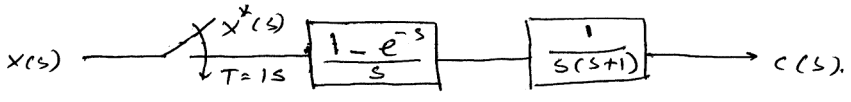
8. a) Solve the following difference equation using the *Z* transform method.

$x(k+2) + 5x(k+1) + 6x(k) = 0$

given $x(0) = 0$, $x(1) = 1$.

b) State & explain Jury's stability test method.

c) Obtain the pulse transfer function of the system shown in the figure.



5 + 5 + 5

9. How does a fuzzy controller differ from a conventional PID controller ? Discuss with suitable block diagram, the conceptual structure of a fuzzy based controller. Mention its field of operation. 5 + 8 + 2

10. a) What do you mean by optimal control laws ?

    b) What is the significance of performance index in design of systems ?

    c) For the system $\dot{x} = -4x + u$, find the optimal control $u(t)$ which drives the system from the initial state $x(0) = 1$ to the terminal state $x(1) = 0$, so as to minimize the performance index

    $$J = \frac{1}{2}\int_0^t u^2 \, dt.$$

    4 + 4 + 7

11. a) Distinguish between the properties of a fuzzy set and a crisp set.

    b) Define the following operations with reference to fuzzy set :

    i) Complement

    ii) Union

    iii) Intersection.

    c) What is meant by defuzzification ? Discuss different methods of diffuzzification with suitable diagram.

    4 + 6 + 5