CONTROL SYSTEMS (SEMESTER - 6)

CS/B.TECH (EE-O)/SEM-6/EE-603/09

1. ..... *Signature of Invigilator*

2. ..... *Signature of the Officer-in-Charge*

Reg. No. | | | | | | | | | | | | | | |

Roll No. of the Candidate | | | | | | | | | | | | | | |

CS/B.TECH (EE-O)/SEM-6/EE-603/09

ENGINEERING & MANAGEMENT EXAMINATIONS, JUNE – 2009

CONTROL SYSTEMS (SEMESTER - 6)

Time : 3 Hours] [Full Marks : 70

INSTRUCTIONS TO THE CANDIDATES :

1. This Booklet is a Question-cum-Answer Booklet. The Booklet consists of **32 pages**. The questions of this concerned subject commence from Page No. 3.
2. a) In **Group – A**, Questions are of Multiple Choice type. You have to write the correct choice in the box provided **against each question**.
   b) For **Groups – B** & **C** you have to answer the questions in the space provided marked 'Answer Sheet'. Questions of **Group – B** are Short answer type. Questions of **Group – C** are Long answer type. Write on both sides of the paper.
3. **Fill in your Roll No. in the box** provided as in your Admit Card before answering the questions.
4. Read the instructions given inside carefully before answering.
5. You should not forget to write the corresponding question numbers while answering.
6. Do not write your name or put any special mark in the booklet that may disclose your identity, which will render you liable to disqualification. Any candidate found copying will be subject to Disciplinary Action under the relevant rules.
7. **Use of Mobile Phone and Programmable Calculator is totally prohibited in the examination hall.**
8. You should return the booklet to the invigilator at the end of the examination and should not take any page of this booklet with you outside the examination hall, **which will lead to disqualification**.
9. Rough work, if necessary is to be done in this booklet only and cross it through.

No additional sheets are to be used and no loose paper will be provided

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FOR OFFICE USE / EVALUATION ONLY

Marks Obtained

	Group – A										Group – B			Group – C			***Total Marks***	***Examiner's Signature***
Question Number																		
Marks Obtained																		

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Head-Examiner/Co-Ordinator/Scrutineer

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Graph sheet is provided on Page 31.

GROUP – A

(Multiple Choice Type Questions)

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

i) The transfer function of the system described by $\frac{d^2y}{dt^2} + \frac{dy}{dt} = \frac{du}{dt} + 2u$ with u as input and y as output is

a) $\frac{s+2}{s(s+1)}$ b) $\frac{s+1}{s^2+s}$

c) $\frac{s+1}{s(1+s)}$ d) $\frac{2s}{s(1+s)}$.

ii) State variable approach converts an n^{th} order system into

a) n 2nd order differential equations

b) two differential equations

c) n 1st order differential equations

d) a lower order system.

iii) $V(x, y) = 25(x - y)^2$, this function is

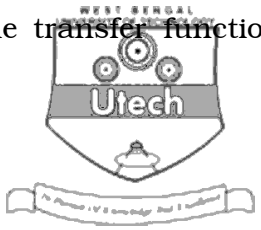
a) positive definite

b) negative definite

c) possitive semi-definte

d) negative semi-definite.

iv) The matrix A of any state space equations for the transfer function $\frac{C(S)}{R(S)}$ of the system shown in the figure below is



dia

a) $\begin{bmatrix} -1 & 0 \\ 0 & -1 \end{bmatrix}$ b) $\begin{bmatrix} 0 & 1 \\ 0 & -1 \end{bmatrix}$

c) $[-1]$ d) $[3]$. ☐

v) One n-order system is fully observable when the observable matrix is of

a) rank $(n-1)$ b) rank n

c) rank 2 d) rank 3. ☐

vi) Describing function analysis is applied to

a) linear system

b) non-linear part of a linear system under any condition

c) when linear part of the non-linear system passes only fundamental component of the signal

d) none of these. ☐

vii) A 5×7 matrix has all entries equal to -1. Rank of the system is

a) 1 b) 7

c) 5 d) 0. ☐

viii) Lyapunov function is

a) energy function b) work function

c) state function d) output function. ☐

ix) Jump resonance characteristic can be found in

a) chaotic system

b) second order non-linear system

c) higher order non-linear system

d) linear time varying system. ☐

x) Phase plane analysis is generally restricted to

a) second order system b) third order system

c) first order system d) any order system. ☐

xi) The input-output characteristic of the control system relay shown in the figure below is

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a) with pure hysteresis b) with dead zone and hysteresis

c) with dead zone d) with on-off switch. ☐

xii) Transfer function of the system described by $\dot{X} = AX + BV$, $Y = CX + DV$ is

a) $D + C\,(SI - A)^{-1}\,B$ b) $B\,(SI - A)^{-1}\,C + B$

c) $B\,(SI - A)^{-1}\,B + C$ d) $B\,(SI - A)^{-1}\,D + B$. ☐

GROUP – B

(Short Answer Type Questions)

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

2. Consider the following transfer function of the system :

$$G(s) = \frac{s + 6}{s^2 + 1{\cdot}8s + 25}$$

Obtain the state space representation of this system in controllable canonical form.

3. Consider the system shown in figure. Derive the difference equation describing the system dynamics when the input voltage applied is piecewise constant.

$e(t) = e(kT)$ for $kT \le t \le (k+1)T$; $T = 1$ sec.

dia

4. Consider the system given by

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 2 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 3 & 1 \end{bmatrix} + \begin{bmatrix} 0 & 1 \\ 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} u_1 \\ u_2 \end{bmatrix} .$$

Check for state controllability.

5. Find out the describing function for an ideal relay.

6. Consider a system with the state model

$$\dot{X} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} x + \begin{bmatrix} 0 \\ 2 \end{bmatrix} u \; ; \quad x(0) = \begin{bmatrix} 0 \\ 1 \end{bmatrix} .$$

Compute the state transition matrix.

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following questions. $3 \times 15 = 45$

7. a) For the system shown in figure, choose $v_1(t)$ and $v_2(t)$ as state variables and write down the state equation satisfied by them. Bring these equations in the vector matrix form.

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b) A system is characterised by the following state equations :

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -3 & 1 \\ -2 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

$$y = [\,1 \quad 0\,] \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} .$$

i) Find the transfer function of the system.

ii) Obtain the solution to the state equation for a unit step input under zero intial conditions. 5 + 10

8. Consider the system shown in figure below :

dia

a) Using the describing function analysis, investigate the possibility of a limit cycle in the system.

b) If a limit cycle is predicted, determine its amplitude and frequency. 7 + 8

9. a) State Lyapunov's direct method of investigating stability of non-linear system.

b) Determine whether or not the following quadratic form is positive definite :

$$Q(x_1, x_2) = 10x_1^2 + 4x_2^2 + x_3^2 + 2x_1 x_2 - 2x_2 x_3 \neq 4x_1 x_3 .$$

c) A linear system is described by the state equations

$$\dot{x} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} x.$$

Investigate the stability of this using Lyapunov's theorem. 4 + 5 + 6

10. a) What is a limit cycle ?

b) What is the limitation of phase plane analysis ?

c) Consider the following non-linear differential equation :

$$\frac{d^2x}{dt^2} + x^2 + \left(\frac{dx}{dt}\right)^2 - 2x + \frac{dx}{dt} = 0$$

Determine the points of equilibrium.

d) Discuss phase plane method of obtaining trajectories for non-linear system.

2 + 2 + 3 + 8

11. a) Consider the system defined by $\dot{X} = AX + BV$, where

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -30 & -11 \end{bmatrix}, \quad B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$

By using feedback control $U = -kx$, it is desired to have closed loop poles at $S = -2, -5$ and -6. Determine the state feedback gain matrix K.

b) The transfer function of a system is given by $\frac{r(s)}{u(s)} = \frac{8}{s(s+2)(s+3)}$. Derive the state equation by using parallel decomposition and draw the signal flow graph. 15

END