CONTROL SYSTEMS
(ECEN 2211)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

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

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) Phase margin of a system is used to specify
(a) Time responese (b) Frequency responese
(c) Absolute stability (d) Relative stability.

(ii) The characteristic equation of a system is $s^2 + 2s + 1 = 0$. The system is
(a) critically damped (b) under damped
(c) undamped (d) over damped.

(iii) The type number of a system with transfer function $T(s) = \frac{s+2}{s^3(s^2+2s+5)}$, is
(a) One (b) Two
(c) Three (d) Four.

(iv) A LTI system obeys
(a) principle of superposition (b) principle of homogeneity
(c) both (a) and (b) (d) none of these.

(v) Which of the following is the analogous quantity for mass element in force-voltage analogy?
(a) Resistance (b) Inductance
(c) Capacitance (d) None of the above.

(vi) The Nyquist plot of a certain feedback system crosses the negative real axis at -0.1, the gain margin of the system is given by
(a) 0.1 (b) 10
(c) 100 (d) None of these.

(vii) The steady error for a Type 2 system subjected to unit ramp input is
(a) 2 (b) 1
(c) 0 (d) Infinity.

(viii) The function 1/(1+sT) has a slope of
(a) -6 dB/ decade (b) 6 dB/decade
(c) -20 dB/decade (d) 20 db/decade.

(ix) The entries in the first column of Routh array of a fourth order system are 5, 2, -0.1, 2, 1. The number of poles in the right half plane is
(a) 1 (b) 2
(c) 3 (d) 4

(x) Given $(s)H(s) = \frac{K}{s(s+1)(s+3)}$. The point of intersection of the asymptotes of the root loci with the real axis is
(a) -4 (b) 1.33
(c) -1.33 (d) 4.

Group – B

2. (a) Find out the overall transfer function of the system in Fig.1, using block diagram reduction technique.

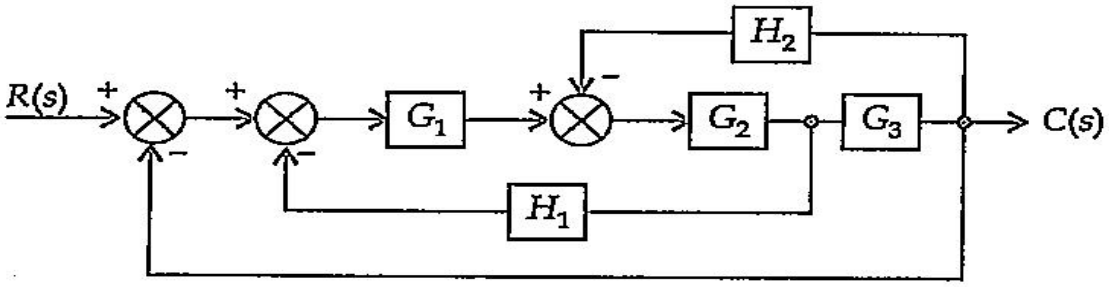

Fig.1 *[(CO2)(Evaluate/HOCQ)]*

(b) Find out the overall transfer function of the system indicated in Fig.2, using Mason's Gain formula.

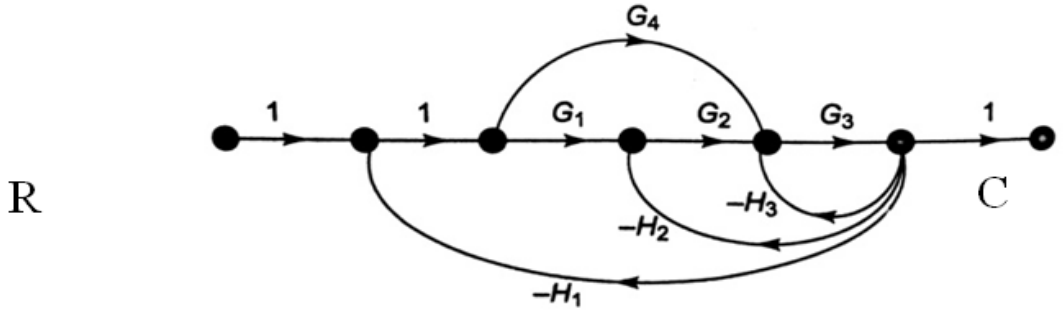

Fig.2

[(CO2)(Remember/LOCQ, Evaluate/HOCQ)]

6 + 6 = 12

3. (a) What is the effect of negative feedback on the stability of a system? Reflect on the advantages of a closed loop system over an open loop one? Define type and order of a system. *[(CO2)(Remember/LOCQ)]*

(b) Draw the mechanical equivalent network of the given figure Fig.3 and also Analyse the analogous electrical circuit using force –voltage analogy.

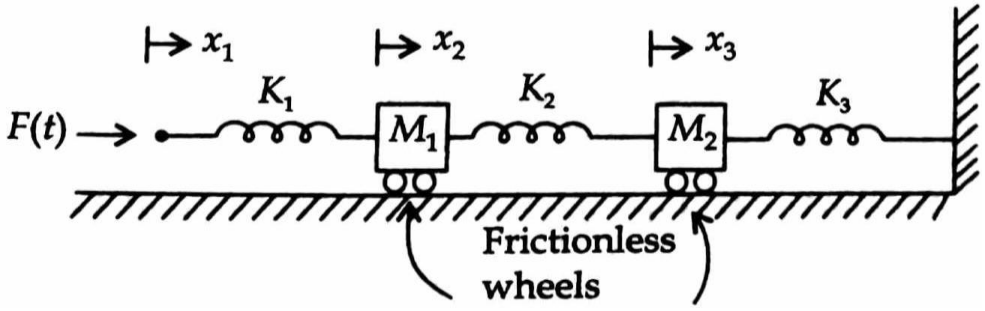

Fig.3 *[(CO1)(Analyse/IOCQ)]*

6 + 6 = 12

Group – C

4. (a) List and define the time response specifications rise time, peak time, peak overshoot and settling time of a second order system step response.

[(CO3)(Remember/LOCQ)]

(b) Using Routh-Hurwitz criterion, find the stability of the system having characteristic equation $s^5 + 2s^4 + 3s^3 + 6s^2 + 10s + 15 = 0$.

[(CO3)(Evaluate/HOCQ)]

8+ 4 = 12

5. (a) Write a short note on absolute stability and relative stability.

[(CO3)(Remember/LOCQ)]

(b) Draw the root locus for the unity feedback system whose open loop transfer function is $G(s) = \frac{k}{s(s+1)(s+3)}$. Determine the value of k for marginal stability and the frequency of sustained oscillation. *[(CO3)(Evaluate/HOCQ)]*

4 + 8 = 12

Group – D

6. The forward path transfer function of a unity feedback control system is given by $G(s)H(s) = \frac{K}{s(1+0.1s)(1+s)}$. Draw the Bode plot. *[(CO4)(Analyze/IOCQ)]*

12

7. The open loop transfer function of a unity feedback system is given by $G(s) = \frac{5}{s(s+1)(s+2)}$. Draw the Nyquist plot and hence comment on its stability.

[(CO4)(Evaluate/HOCQ)]

12

Group – E

8. (a) A system is represented by the following state and output equation:

$$\dot{X} = \begin{bmatrix} -0.5 & 0 \\ 0 & -2 \end{bmatrix} X + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t)$$

$$Y = \begin{bmatrix} 0 & 1 \end{bmatrix} X$$

Test for Controllability and Observability of the system. *[(CO5)(Evaluate/HOCQ)]*

(b) Find the transfer function of the system that is represented as

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

$$Y = \begin{bmatrix} 1 & 0 \end{bmatrix} X$$

[(CO5)(Evaluate/HOCQ)]

6 + 6 = 12

9. Write short notes on any three: **(4 × 3) = 12**
   (i) PI and PD controller
   (ii) Gain margin and Phase margin
   (iii) Position, Velocity and Acceleration error
   (iv) Time domain specifications of a second order system
   (v) Eigenvalue.

[CO6, Remember,Understand/LOCQ]

Cognition Level	*LOCQ*	*IOCQ*	*HOCQ*
Percentage distribution	*22.92*	*17.71*	*59.37*

Course Outcome (CO):

After the completion of the course students will be able to

1. Students will be able to relate their pre-requisite knowledge from Mathematics and Signals & Systems.
2. They will develop the ability to understand mathematical model of physical systems and study their nature, configuration and relevant mapping into equivalent models.
3. The concept and classification of control systems, will be applied to identify, analyze and solve stability related issues in time response, error analysis and stability analysis in an advanced way.
4. Students will be able to evaluate, categorize and justify the margin of stability with respect to the system's nature using frequency domain analysis tools.
5. Students will be able to conceptualize different methods of evaluating system behavior with the help of models compatible to simulation.
6. Students will be able to design controllers according to desired performance specifications which can be applied for system design in higher semesters.

**LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.*