CONTROL SYSTEMS
(ECEN 3102)

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

(ii) Given $G(s)=\frac{k}{s^2(s+2)(s+3)}$, the type and order of the system is
(a) 3 and 3 (b) 3 and 0 (c) 2 and 4 (d) 3 and 1.

(iii) If the maximum overshoot is 100% the damping ratio is
(a) 1 (b) 0 (c) 0.5 (d) Infinite

(iv) The characteristic equation of a unity feedback system is given by $s^3+s^2+4s+4=0$. The system has
(a) One pole in the RHS of the s plane (b) No poles in the RHS of the s plane
(c) Exhibits oscillatory nature (d) Both (b) and (c).

(v) The type of a transfer function denotes the number of
(a) Zeros at the origin (b) Poles at infinity
(c) Poles at the origin (d) None of these.

(vi) The initial slope of the Bode plot gives an indication of
(a) Type of system (b) Order of system
(c) Stability (d) Gain margin.

(vii) Addition of a pole to the closed loop transfer function
(a) Increases rise time (b) Decreases rise time
(c) Increases overshoot (d) Has no effect.

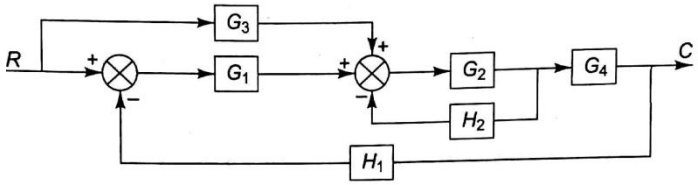
(viii) The system represented by its transfer function has multiple poles lying on its imaginary axis of the s plane. The system is
(a) Absolutely stable (b) Marginally stable
(c) Unstable (d) Cannot comment on stability from given information

(ix) The steady state error of unit ramp input in type two system is
(a) Infinite (b) Zero (c) One (d) Five.

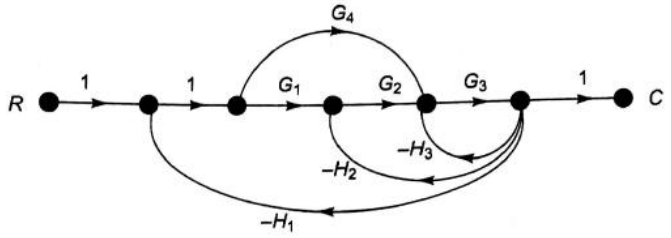
(x) The phase margin of a system is used to specify
(a) Time response (b) Frequency response
(c) Absolute stability (d) Relative stability.

Group – B

2. (a) Find out the overall transfer function of the system using block diagram reduction technique. [(CO2)(Analyze/IOCQ)]



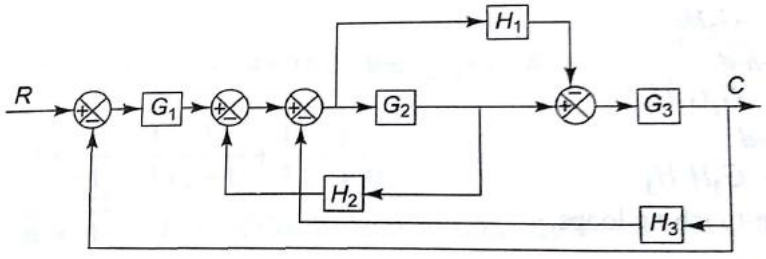
(b) Find out the overall transfer function using Mason's Gain formula. [(CO2)(Analyze/IOCQ)]



6 + 6 = 12

3. (a) Define the following and give examples:
(i) Linear system
(ii) Time varying system. [(CO1)(Remember/LOCQ)]

(b) Use Mason's gain formula to evaluate the overall transfer function of the following block diagram. [(CO2)(Analyse/IOCQ)]



(3 + 3) + 6 = 12

Group – C

4. (a) A unity feedback system has $G(s) = \dfrac{k}{s(s+6)}$, and input $r(t) = 4t$

Determine the steady state error for k=180. [(CO3) (Evaluate/HOCQ)]

(b) The characteristic equation of a system is given by $s^3 + 3ks^2 + (k+2)s + 4 = 0$. Find the range of k for which the system is stable. [(CO3) (Evaluate/HOCQ)]

6 + 6 = 12

5. 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) (Analyze/IOCQ)]

12

Group – D

6. Sketch the Bode plot for the system having open loop transfer function $G(s)=\frac{100(s+10)}{s(s+5)(s+20)}$. [(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:

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

$$Y=\begin{bmatrix}1 & 2\end{bmatrix}X$$

Find the poles of the system. [(CO5) (Analyze/IOCQ)]

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

$$\dot{X}=\begin{bmatrix}-5 & -1\\ 3 & -1\end{bmatrix}X+\begin{bmatrix}2\\5\end{bmatrix}u(t)$$

$$Y=\begin{bmatrix}1 & 2\end{bmatrix}X$$ [(CO5)(Analyze/IOCQ)]

6 + 6 = 12

9. Write short notes on any three: **(3 × 4) = 12**
   (i) PI and PD controller
   (ii) Gain margin and Phase margin
   (iii) Nyquist stability criterion
   (iv) Time domain specifications of a second order system. [(CO6) (Remember/LOCQ)]

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	18.75%	56.25%	25%

Course Outcome (CO):

After the completion of the course students will be able to

1. Apply their previous knowledge of Mathematics and Signals & Systems.
2. Understand mathematical models of physical systems and study their nature, configuration and relevant mapping into equivalent models.

3. Apply the concept and classification of control systems to identify, analyze and solve stability related issues in time response, error analysis and stability analysis in an advanced way.
4. Evaluate, categorize and justify the margin of stability with respect to the system's nature using frequency domain analysis tools.
5. Categorize different methods of evaluating system behavior with the help of simulation models.
6. Design controllers according to desired performance specifications which can be applied to system design in higher semesters.

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

Department & Section	Submission Link
ECE - BACKLOG	https://classroom.google.com/c/NDYzMzAyNzc2NDA4/a/NDY5Mjc3MDIxMzUx/details