CONTROL SYSTEMS & PRACTICE
(ECEN 3135)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

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

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) A system is stable for (where GM = Gain Margin and PM = Phase Margin)
(a) GM and PM both positive (b) GM and PM both negative
(c) GM negative (d) PM negative

(ii) Time taken for the response to rise from zero to 100 % for very first time is called
(a) Rise time (b) Peak time (c) Settling time (d) Delay time

(iii) Which of the following matrices is responsible for defining how the input affects the state in a state-space model?
(a) Matrix A (b) Matrix B (c) Matrix C (d) Matrix D

(iv) A second-order system has a damping ratio $\zeta=0.7$ and a natural frequency $\omega n=5$ rad/s. What is the damped natural frequency ωd?
(a) 2 rad/s (b) 3.5 rad/s (c) 5 rad/s (d) 4 rad/s

(v) A lag network for compensation normally consists of
(a) R, L and C elements (b) R and L elements
(c) R and C elements (d) R only

(vi) In closed loop control system with negative feedback, the overall gain of the system will
(a) Decrease (b) Increase (c) Remain unaffected (d) Any of the above

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

(viii) Which of the following is a standard test signal used in time-domain analysis?
(a) The system is overdamped
(b) The system has a constant steady-state error
(c) The system has a type 1 characteristic, implying zero steady-state error for a step input
(d) The system will exhibit an oscillatory response

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

(x) For a second-order system with the transfer function $\boldsymbol{G(s)} = \frac{\mathbf{10}}{(s^2+4s+25)}$, what is the undamped natural frequency?
(a) 2 rad/s (b) 3 rad/s (c) 5 rad/s (d) 25 rad/s

Fill in the blanks with the correct word

(xi) If all the roots of the characteristic equation lie on the left half of the s-plane, the system is _____.

(xii) A Bode plot is a graphical representation of a system's frequency response, showing magnitude and _____ as a function of frequency.

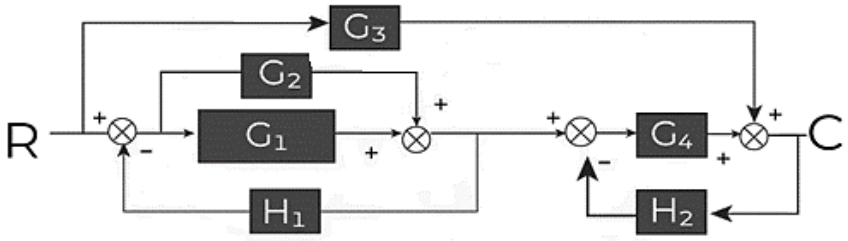
(xiii) Lead network is used to improve _____ response.

(xiv) The factor $1/j\omega$ has a phase angle of _____.

(xv) The closed loop transfer function of a control system is $9/(s^2 + 3s + 9)$, then the type of the system is _____.

Group - B

2. (a) Use block diagram reduction technique to achieve the overall transfer functions for the following system. Also obtain the signal flow graph of the system.



[(CO1)(Apply/IOCQ)]

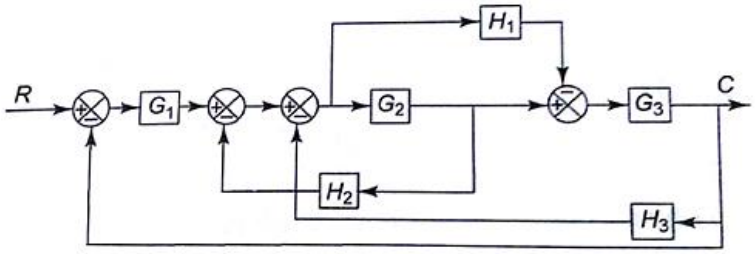
(b) Explain Mason's gain formula for signal flow reduction technique.
[(CO1)(Remember/LOCQ)]

(c) What will be the change in overall transfer function if a take-off point is moved ahead of a block?
[(CO1)(Understand/LOCQ)]

8 + 2 + 2 = 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) What do you understand by transient response and steady state response of a system? Derive the expression for peak time for a second order system. *[(CO3)(Remember/LOCQ)]*

   (b) Using Routh-Hurwitz criterion, find the stability of the system having characteristic equation $s^6 + 2s^5 + 8s^4 + 12s^3 + 20s^2 + 16s + 16 = 0$. *[(CO3)(Evaluate/HOCQ)]*

(4 + 3) + 5 = 12

5. (a) The open loop transfer function of a unity feedback system is given by $G(s) = \frac{Ks}{(s+4)(s^2+s+1)}$.

   (i) Find the range of k for which the system is stable.

   (ii) Determine the value of k which will cause sustained oscillation

   (iii) Find the frequency of oscillation. *[(CO3)(Evaluate/HOCQ)]*

   (b) A feedback system has $T(s)=16s^2+4s+16$ and $H(s)=ks$ The damping factor of the system is 0.8.

   Determine the overshoot of the system and the value of k. *[(CO3)(Evaluate/HOCQ)]*

8 + 4 = 12

Group - D

6. (a) 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)]*

   (b) Define relative stability. *[(CO4)(Remember/LOCQ)]*

10 + 2 = 12

7. Draw the Bode plot for a unity negative system having open loop transfer function

$$G(s)H(s) = \frac{10}{s(s+1)(1+0.1s)}$$

   Determine the Gain margin and phase margin of the system. *[(CO4)(Analyze/IOCQ)]*

12

Group - E

8. (a) A single input single output system is given by

$$\dot{x}(t)=\begin{bmatrix}-1 & 0\\ 0 & -2\end{bmatrix} x(t) + \begin{bmatrix}1\\1\end{bmatrix} u(t);\ y=[1 \quad 0\ ]x(t)$$

   Comment on controllability and observability of the system. *[(CO5)(Evaluate/HOCQ)]*

   (b) What are the advantages of state space analysis? Write the general form of state variable matrix. *[(CO4)(Remember/LOCQ)]*

(3 + 3) + (3 + 3) = 12

9. (a) Write short note on PD and PID Controller. *[(CO6)(Remember/LOCQ)]*

   (b) A system is described by the following matrices:

$A=\begin{bmatrix}0 & 1\\ 1 & 0\end{bmatrix}$, $B=\begin{bmatrix}0\\ 1\end{bmatrix}$, C= [1 2]. Determine the transfer function. *[(CO5)(Evaluate/HOCQ)]*

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	32.3	27	40.6