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) If the gain of an open loop system is doubled, the gain margin
(a) is not affected (b) gets doubled
(c) becomes half (d) becomes $1/4^{th}$.

(ii) The transfer function of a plant is $(s) = \frac{1}{s^3+0.2s+1}$. The plant settling time for a step input when it settles to within 2% of its final value is
(a) 20 s (b) 40 s
(c) 35 s (d) 45 s.

(iii) 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).

(iv) 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.

(v) With use of PD controller, the rise time of the system
(a) decreases (b) increases
(c) remains same (d) none of these.

(vi) Given $G(s) = \frac{10}{s^2(s+1)(s+4)}$, the type and order of the system is
(a) 3 and 3 (b) 3 and 0
(c) 2 and 4 (d) 3 and 1

(vii) The phase margin of a system is used to specify
(a) time response (b) frequency response
(c) absolute stability (d) relative stability.

(viii) The function $1/(1+s^2T)$ has a slope of
(a) -40dB/ decade (b) 40 dB/decade
(c) -20 dB/decade (d) 20 db/decade.

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

(x) 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.

Fill in the blanks with the correct word

(xi) The Laplace transform of u(t) is _____.

(xii) For a type-3 system, the asymptote at a lower frequency will have a slope of _____ dB/decade.

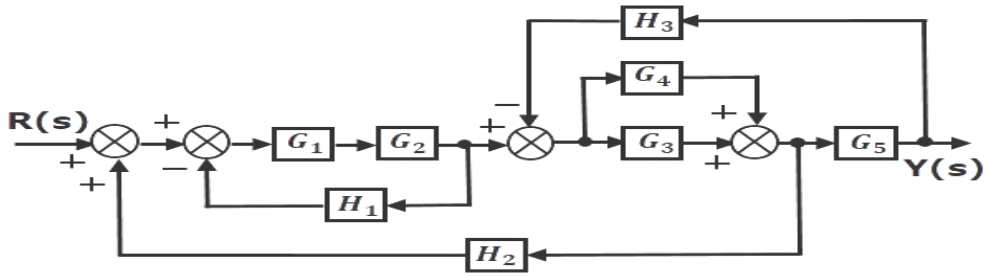
(xiii) For an _____ system, damping factor is greater than unity.

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

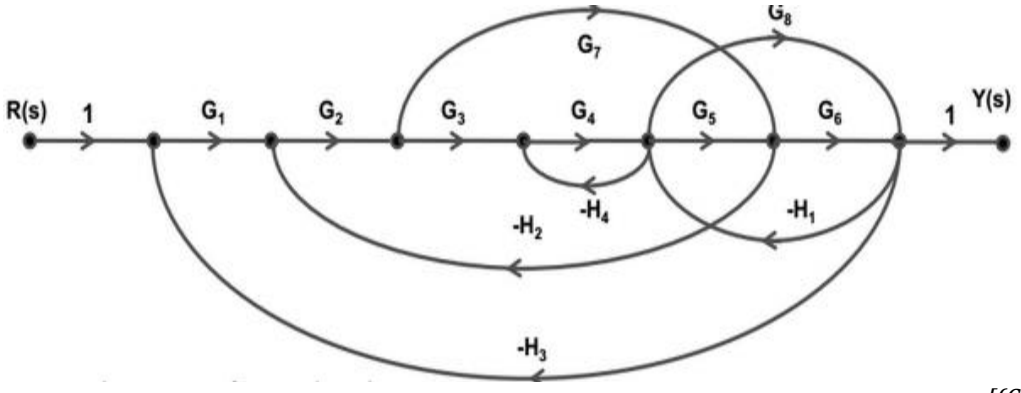
(xv) If the gain margin of a certain feedback system is given by 20dB, the Nyquist Plot will cross the negative real axis at the point _____.

Group- B

2. (a) Evaluate the transfer function $\frac{Y(s)}{R(s)}$ for the following figure using block diagram reduction technique. *[(CO2)(Evaluate/HOCQ)]*



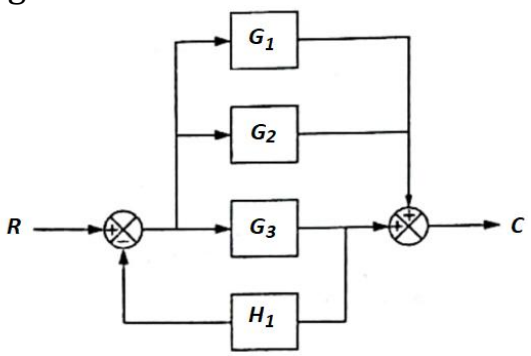
(b) Draw the corresponding block diagram for the following signal flow graph.



[(CO1)(Analyse/IOCQ)]

7 + 5 = 12

3. (a) Use Mason's gain formula to evaluate the overall transfer function of the following block diagram.



[(CO2)(Apply/IOCQ)]

(b) Explain what is an LTI system and cite a relevant example. *[(CO1)(Remember/LOCQ)]*

(c) List the advantages of a closed loop system over an open loop system. *[(CO1)(Remember/LOCQ)]*

6 + 3 + 3 = 12

Group - C

4. (a) Sketch the Root locus for the system which has the open-loop transfer G(s)H(s)= $\frac{K(s+2)(s+3)}{s(s+1)}$. Evaluate the (i) Break-away point, (ii) value of K for stability. *[(CO3)(Evaluate/HOCQ)]*

(b) Using Routh-Hurwitz Criterion, comment on the stability of a system having the characteristic equation $s^5+2s^4+3s^3+6s^2+10s+15=0$. Identify how many poles are lying on the right-hand side if the system is unstable. *[(CO3)(Evaluate/HOCQ)]*

8 + 4 = 12

5. (a) List and define the time response specifications rise time, peak time, peak overshoot and settling time of a second order system with step response. *[(CO3)(Remember/LOCQ)]*

(b) Derive the expression of rise time for an underdamped second order system. *[(CO3)(understand/LOCQ)]*

(c) A unity feedback system has $G(s)=\frac{K}{s(s+6)}$, and input r(t)=4t. Determine:

(i) Steady state error for k=180.

(ii) The value of k to reduce error by 6%. *[(CO3)(Evaluate/HOCQ)]*

4 + 3 + 5 = 12

Group - D

6. Draw the Bode plot of the system having open loop transfer function $G(s)=\frac{10(s+10)}{s^2+3s}$. *[(CO4)(Analyze/IOCQ)]*

12

7. (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

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)(Apply/IOCQ)]*

6 + 6 = 12

9. Write short notes on any three: **(3 × 4) = 12**
   (i) Gain cross-over frequency and Phase cross-over frequency
   (ii) Error co-efficients
   (iii) Lead compensator
   (iv) PI and PD controller
   (v) Controllability and Observability. *[CO6,Remember,Understand/LOCQ]*

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	28.12	36.46	35.42

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*