

**LINEAR CONTROL SYSTEM
(ELE3103)**

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) Which of the following has a closed loop configuration?
(a) Field controlled D.C servo motor (b) Armature controlled D.C servo motor
(c) Both a and b (d) D.C series motor
- (ii) The transfer function of a system is $G(s) = \frac{K}{s^3(1+Ts)}$. The type and order of the system are
(a) 4 and 3 (b) 3 and 4
(c) 3 and 3 (d) 2 and 3
- (iii) For a system having a transfer function $G(s) = \frac{K}{s(s^2+2s+20)}$ the angle of asymptotes will be
(a) 60°, 180°, 120° (b) 60°, 180°, 300°
(c) 60°, 180°, 200° (d) 60°, 150°, 300°
- (iv) The steady state error of a type-0 system due to unit step input is
(a) zero (b) ∞
(c) constant (d) -∞
- (v) Steady state error of a system does not depend on
(a) Nonlinearities (b) Type of a system
(c) Nature of input (d) Order of a system
- (vi) The radius of Nyquist contour is
(a) 25 (b) 1
(c) 0 (d) ∞
- (vii) If the gain margin of a unity feedback control system is zero, then the Nyquist plot of the system passes through
(a) The origin in GH plane
(b) Left hand side of (-1,j0) point in the GH plane
(c) (-1,j0) point in the GH plane
(d) In between origin and (-1,j0) point in the GH plane

- (viii) By the use of PI control to a second order system the steady state error
 (a) Decreases (b) Increases
 (c) Can't be determined (d) Remains unaltered
- (ix) State variable analysis has several advantages over transfer function approach as:
 (a) It is applicable for linear and non-linear and variant and time-invariant system
 (b) It is for the analysis of MIMO system
 (c) It takes initial conditions of the system into account
 (d) All of the above
- (x) The Eigen values of the matrix $A = \begin{bmatrix} 1 & 3 \\ 3 & 1 \end{bmatrix}$ are
 (a) - 2 and 4 (b) -4 and 4
 (c) -2 and -4 (d) 2 and -2

Fill in the blanks with the correct word

- (xi) A system is said to be linear if it follows_____.
- (xii) The centroid of asymptotes of a system whose loop transfer function $G(s)H(s) = \frac{1}{(s+1)(s+2)(s+6)}$ is located at _____.
- (xiii) The steady state error of a system $G(s) = \frac{1}{s(s+3)}$ with unity negative feedback for a unit ramp input is _____.
- (xiv) The system whose loop transfer function $G(s)H(s) = \frac{1}{s^3-5s^2+3s}$ has _____ number of unstable open loop poles.
- (xv) In state variable analysis response due in initial condition is also known as _____.

Group - B

2. (a) Solve the block diagram shown in Fig. 1 by block diagram reduction technique and determine the overall transfer function $(C(s)/R(s))$. [[CO1](Analyse/IOCQ)]

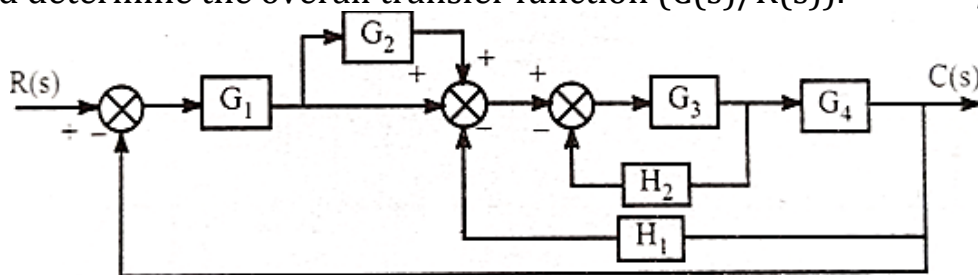


Fig. 1

- (b) Sketch the signal flow graph of the above block diagram. From the signal flow graph identify the transfer function $C(s)/R(s)$ using Masson's gain formula. [[CO1](Analyse/IOCQ)]
6 + (2 + 4) = 12

3. Consider the armature controlled DC servo mechanism with potentiometric error detector. Assume that the input to the system is the reference shaft position θ_R and the system output is the load shaft position θ_L . Draw the block diagram of the system

indicating transfer function of each block. Simplify the block diagram to obtain overall transfer function.

[[CO1](Analyse/IOCQ)]

12

Group - C

4. (a) What do you mean by steady state error? List down the factors which affects the steady state error. [[CO2](Remember/LOCQ)]
- (b) Determine the value of 'K' and 'a' such that the system has a damping ratio of 0.7 and an undamped natural frequency of 4 rad/sec for the system shown in Fig. 2. Hence find out the peak time of the system.

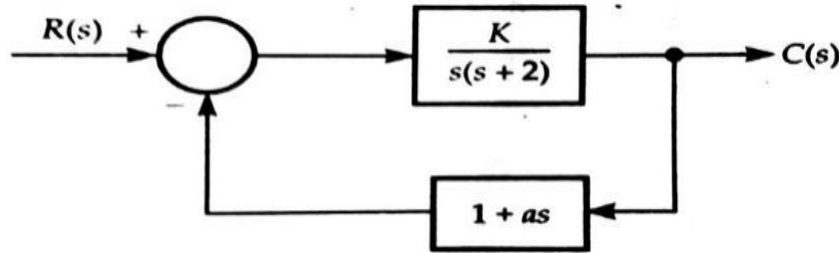


Fig. 2

[[CO2](Analyse/IOCQ)]

- (c) A unity negative feedback control system has $G(s) = \frac{K e^{-2s}}{s(s^2+5s+9)}$. Using Routh stability criterion find
- The range of K for which system is stable
 - The value of K for which system is critically stable
 - Frequency of oscillation.

[[CO3](Apply/IOCQ)]

$$2 + 4 + (4 + 1 + 1) = 12$$

5. (a) What do you mean by angle of departure? [[CO3](Understand/LOCQ)]
- (b) Sketch the root locus diagram of a negative unity feedback system whose open loop transfer function is given by $G(s)H(s) = \frac{K(s^2+4s+5)}{s(s+1)}$. Identify (i) the range of K for which system is stable, (ii) angle of arrival at complex zeros, (iii) break away points if any. [[CO3](Analyse/IOCQ)]

$$2 + (5 + 1 + 2 + 2) = 12$$

Group - D

6. (a) What is 'Principle of Argument' in Nyquist plot? [[CO4](Remember/LOCQ)]
- (b) State Nyquist Stability Criterion. [[CO4](Remember/LOCQ)]
- (c) The open loop transfer function of a unity feedback system is given by $G(s)H(s) = \frac{100}{s(s+1)(s+4)}$. Develop the Nyquist plot and explain the stability of the closed loop system. [[CO4](Evaluate/HOCQ)]

$$2 + 2 + 8 = 12$$

7. The open loop transfer function of a unity feedback system is given by,

$$G(s)H(s) = \frac{K}{s(1 + 0.5s)(1 + 0.25s)}$$

Determine the value of K such that (a) Gain margin=10 dB and (b) phase margin=50°.

[[CO4](Analyze/IOCQ)]

(6 + 6) = 12

Group - E

8. (a) How PI control action improves various time domain indices of a 2nd order system? Explain with suitable example. [[CO5](Remember/LOCQ)]
 (b) Determine the controllable canonical form of the system whose transfer function is given by,

$$G(s) = \frac{3s^2 + 4s + 2}{s^3 + 3s^2 + 2s + 2}$$

Hence draw the signal flow graph of the system realized in controllable canonical form.

[[CO6](Analyze/IOCQ)]

4 + (6 + 2) = 12

9. (a) A system is described by,

$$\dot{X} = \begin{bmatrix} 0 & 1 \\ 0 & -4 \end{bmatrix} X + \begin{bmatrix} 0 \\ 2 \end{bmatrix} U \quad \text{and} \quad Y = [0 \quad 2] X$$

Examine the controllability and observability of the system.

[[CO6](Analyze /IOCQ)]

- (b) Formulate the diagonalized form the following system.

$$\dot{X} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} X + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} U \quad \text{and} \quad Y = [4 \quad 5 \quad 1] X$$

[[CO6](Evaluate/HOCQ)]

4 + 8 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	18.75	64.58	16.67