Ref No. : **Ex/EE/5/T/314/2024**

Bachelor of Engineering (Electrical Engineering), 3rd Year 1st Sem. Exam, 2024

SUBJECT : LINEAR CONTROL SYSTEM

Time: Three Hours Full Marks: 100 (50 each part)

Use a separate Answer-Script for each part

Question No.	**PART - I**	**Marks**
	Answer question no. 1 and any two from the rest	
1. (a)	What is the order and type of the following system? $$G(s) = \frac{s^4+1}{s^5+s}$$	**2+4+6 +3+3+2**
(b)	What are the two notions of stability of a linear system?	
(c)	Define the terms: absolute stability, conditional stability and relative stability.	
(d)	State and explain whether a practically realizable system can have ode number of complex poles (with imaginary part).	
(e)	Give a practical example of almost a marginally stable system.	
(f)	What is the significance of break-away point?	
2.(a)	By means of the Routh criterion determine the stability of the system represented by the following characteristics equation. If the system is found unstable, determine the number of roots of the characteristics equation in the right half of the s-plane. $$s^5 + s^4 + 3s^3 + 9s^2 + 16s + 10 = 0$$	**7+8**
(b)	The open-loop transfer function of a unity –ve feedback control system is given by $$G(s) = \frac{K}{(s+2)(s+4)(s^2+6s+25)}$$ By applying the Routh criterion, discuss the stability of the closed-loop system as a function of K. Determine the values of K which cause the sustained oscillation in the closed-loop system. What are the corresponding oscillation frequencies?	

[Turn over

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PART - I

Question No.		Marks
3.	A feedback control system has an open-loop transfer function $$Gs)H(s) = \frac{K}{s(s+2)(s^2+2s+2)}$$ Construct the root loci as K is varied from 0 to ∞. Use mm-graph paper. Axes and root loci must be shown in bold lines.	**15**
4.	Sketch asymptotic Bode magnitude (dB) and phase (Degree) plot of a feedback control system which has the following open-loop transfer function. Determine the gain crossover frequency (ω_g) and phase margin (PM). Use semi-log graph paper. $$Gs)H(s) = \frac{75(1+0.2s)}{s(s^2+16s+100)}$$	**15**
5. (a)	State and explain Nyquist stability criterion.	**6+9**
(b)	By using Nyquist stability criterion determine the stability of a feedback control system with an open loop transfer function $$G(s)H(s) = \frac{s+2}{(s+1)(s-1)}$$	

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BACHELOR OF ENGINEERING (ELECTRICAL ENGINEERING)

3RD YEAR 1ST SEMESTER EXAMINATION, 2024

Subject: LINEAR CONTROL SYSTEM **Time: 3 Hours** **Full Marks: 100**

Use a separate Answer-script for each Part

Part II (50 marks)

Question 1 is compulsory

Answer ***Any Two*** questions from the rest (2×20)

Question No.			Marks
Q1		Answer ***any Two*** of the following:	
	(a)	Enumerate the beneficial effects of Feedback in control systems over the open-loop control systems.	5
	(b)	Why PID controller is called a "Gain-Reset-Preact Controller"?	5
	(c)	Discuss the effect of feedback on the following aspect of a control system: sensitivity to parameter variations.	5
	(d)	What is State Transition Matrix of a system?	5
Q2	(a)	Show how feedback can be used to modify the dynamic response of a system.	4
	(b)	For a closed loop unity feedback system with forward path transfer function $$G(s) = \frac{k}{s(s+6)}$$ Find the values of the gain k such that the following responses are achieved: (i) under-damped with ζ=0.75 and (ii) critically-damped.	2+2
	(c)	Define Type of a system?	2
		For a unity feedback system define the following terms and find the expressions for steady-state error in response to Step, Ramp and Parabolic inputs in terms of these constants: (i) Static position error constant (ii) Static velocity error constant (iii) Static acceleration error constant	6
	(d)	Justify the following statement: For a type-0 system, PI-controller can eliminate the steady-state offset for step input while P-controller can only reduce it.	4

[Turn over

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Q3 (a) Define State and Output equations for an LTI system. 2

For n-th order SISO, LTI system indicate the dimensions of the matrices and vectors involved in State and Output equations. 4

(b) Consider an LTI system given by the differential equation:

$$2\frac{d^3y(t)}{dt^3} + 4\frac{d^2y(t)}{dt^2} + 6\frac{dy(t)}{dt} + 8y(t) = 10\frac{du(t)}{dt} + 3u(t)$$

(i) Obtain the state-space model of the system in the Controllable Canonical Form. 4

(ii) Draw the corresponding block diagram indicating the individual state variables. 4

(c) Given a system with the state equation: 6

$$\dot{x} = Ax,$$

$$\text{with, } A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$$

Obtain the State Transition Matrix for the system.

Q4 (a) Define complete *State Controllability* and *Observability*. 4

State the *Necessary and Sufficient* conditions for the same in respect of LTI systems. 4

(b) Consider a system given by the following state equation:

$$\dot{x} = Ax + Bu,$$

$$\text{with, } A = \begin{bmatrix} -3 & 1 \\ -2 & 1.5 \end{bmatrix}, B = \begin{bmatrix} 1 \\ 4 \end{bmatrix}$$

(i) Determine whether the system is completely state controllable. 4

(ii) Justify the answer in terms of the condition for state controllability in s-plane. 4

(c) State and discuss the *Principle of Duality* in respect of controllability and observability. 4

Q5 (a) (i) What is a *State Observer*? 2

(ii) Draw the block diagram of a system and a full-order state observer. 4

(iii) Derive the equations that describes the dynamic behaviour of a full-order state observer. 4

(b) Consider the system given by 10

$$\dot{x} = Ax + Bu$$

where

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -5 & -6 \end{bmatrix}, \quad B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$

By using the state-feedback control

$$u(t) = -Kx$$

it is desired to have the closed-loop poles at $s = -2 \pm j4$ and $s = -10$.

Determine the state-feedback gain matrix K.