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

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

SUBJECT : LINEAR CONTROL SYSTEM

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

Use a separate Answer-Script for each part

PART - I

Question No.		**Marks**
	Answer question no. 1 and any two from the rest	
1. (a)	What is the order and type of the following system? $$G(s) = \frac{s^4 + 16}{s^5 + s}$$	**2+4+6 +3+3+2**
(b)	Explain Asymptotic and BIBO stability for 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 break-away point determined?	
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. $$s^5 + 2s^4 + 3s^3 + 9s^2 + 16s + 25 = 0$$	**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 $$Gs)H(s) = \frac{K}{s(s+2)(s^2+2s+4)}$$ 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 SUPPLEMENTARY 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)	What are the major limitations of Open-loop Control system and how they can be overcome by using Closed-loop Control scheme?	5
	(b)	Why PID controller is called a "Gain-Reset-Preact Controller"?	5
	(c)	Discuss the effect of feedback on the speed of response of a control system.	5
	(d)	What is State Transition Matrix of a system?	5
Q2	(a)	(i) Define Sensitivity of a system with respect to variations in its parameter values.	2
		(ii) Show how feedback can be used to reduce the sensitivity of parameter variations in respect of changes in the plant parameters.	4
	(b)	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
	(c)	For an LTI system given by the transfer function: $G(s) = \dfrac{(s+3.15)}{s(s+1.5)(s+0.5)}$ calculate the static position, velocity and acceleration error constants and the steady state errors in response to Step, Ramp and Parabolic inputs.	6

[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 a system given by the following state and output equations:

$$\dot{\boldsymbol{x}} = \boldsymbol{A}\boldsymbol{x} + \boldsymbol{B}\boldsymbol{u}$$

$$\boldsymbol{y} = \boldsymbol{C}\boldsymbol{x}$$ 6

Derive, stating the necessary assumptions, the expression for the transfer function.

(c) Consider an LTI system given by the transfer function:

$$G(s) = \frac{s^2 + 2s + 3}{s^3 + 6s^2 + 5s + 20}$$ 8

Obtain the state-space model of the system in the phase variable canonical form.

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

State the *Necessary and Sufficient* conditions for complete *State Controllability* of LTI systems. 2

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

(c) (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

Q5 (a) For a type-0 system, explain how PI-controller can eliminate the steady-state offset while P-controller can only reduce it. 4

(b) Describe, stating the necessary assumptions, the Ziegler Nichols methods of PID controller tuning. 8

(c) Consider a control system in which a PID controller is used to control the plant

$$G(s) = \frac{1}{s(s+1)(s+5)}$$ 8

Determine the parameters of PID controller by Ziegler-Nichols tuning rule.