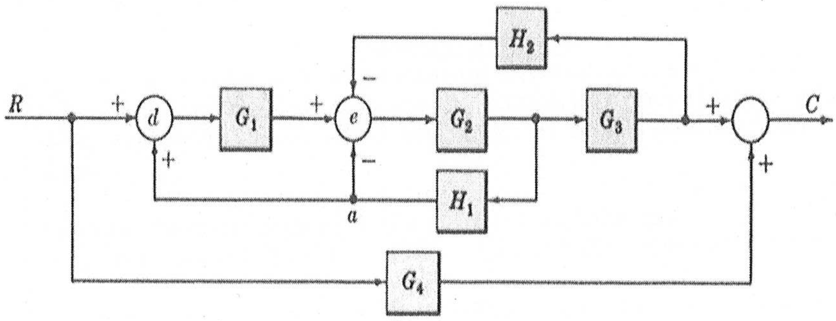
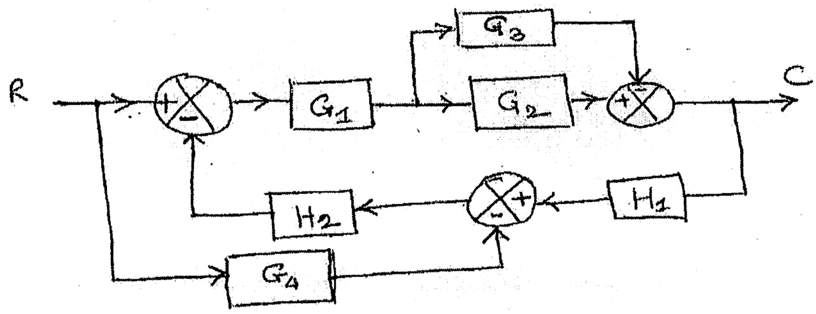
Ref. No.: Ex/IEE/PC/B/T/224/2024

B.I.E.E. 2nd Yr. 2nd Semester Examination, 2024

SUBJECT: Linear Control Systems

Time: Three hours | Full Marks 100

All Modules are Compulsory. Stepwise marking will be done.

Q.No.		Marks
	Module I (CO1)	
1.	a) Determine the force-voltage analogy of a translational mechanical system (using free body diagram) and a gear train from the first principles. OR Derive system equations for the outlet temperature of a thermal system in terms of input temperature variation and change in inlet heat flow rate from basic principles. Draw the two-input system block diagram and identify its electrical equivalent set of parameters.	5
	b) Derive system equations and draw the block diagram of a two phase a.c. servomotor OR a field controlled d.c. servomotor.	5
2.	For the system in Fig.1a OR Fig. 1b, derive the transfer function using block diagram reduction technique, draw the equivalent signal flow graph and use Mason's gain formula to find the transfer function.  Fig.1a  Fig. 1b	5+5+5

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Q.No.		Marks
	Module 2 (CO2)	
3.	a) Consider a unity feedback system with forward path TFs $G_1(s) = K/(s+b)$ and $G_2(s) = 1/s(s+a)$. Determine the closed loop TF T(s) of the system. Determine (i) S^T_K, S^T_a OR (ii) S^T_K, S^T_b.	5
	b) Show the pole locations of (any two) : 2 systems with a) same σ, b) same ζ, c) same ω_d, while the other parameters are different. For each of the two chosen scenarios, show the comparative time domain responses of the systems and justify in terms of M_p, t_s etc.	6
4.	a) When subjected to an unit-step input, the response of a system is $1+0.2\exp(-60t) - 1.2\exp(-10t)$. Obtain the closed loop function and determine ω_n and ξ.	4
	b) Consider that a unity feedback closed loop feedback control system has the TF $G(s) = 5(s+1)/\{s^2(s+12)(s+5)\}$. Compute steady state errors for unit step, ramp and parabolic inputs. OR Identify type of system for a closed loop unity feedback control with $G_1(s) = (s+2)/(s+4)$ and $G_2(s) = 4/s(s+1)$. Compute the error constants and steady state errors for unit step, ramp and parabolic inputs.	5
	Module 3 (CO3)	
5.	a) For the system with characteristic equation $s^3+3s^2+2s+(K-24)=0$ OR. $s^3+15s^2+50s+K=0$, provide the complete Routh-Hurwitz array. Also determine ω_c, K_c, GM and range of K for stability from the array.	5+2
	b) Draw the root locus plot of a system with loop gain $GH(s) = K(s+6)/(s+3)^2$ OR $GH(s) = K(s+4)(s+6)/s(s+2)$.	8
	c) For the system with $GH(s)=1/s(5s+1)$ OR $GH(s) = 10/s(s+1)(s+2)$, draw the Nyquist contour, showing the poles-zeros and mark the segments. Derive the real and imaginary intercepts/crossings of the polar plot. Derive the Nyquist plot for each segment and draw the total Nyquist plot. Name the plane, provide axis labels and units for the plots.	3+5+2
6.	For the system having open loop TF $GH(s) = 160(s+1)/s^2(s^2+4s+16)$ OR $GH(s) = 200/(s+2)(s+4)(s+5)$, a) Identify critical frequencies and provide table for calculated and graphically obtained gain and phase values at these frequencies. b) Draw the Bode (asymptotic) magnitude and (actual) phase plots. Provide axis labels, units for both plots. c) Show ω_g, ω_p, GM and PM in the plots and provide their values. d) Comment on system stability.	2+2+2 +4 +5

Q.No.		Marks
	Module 4 (CO4)	
7.	a) For a system with $GH(s) = K(s+2) / (s^2+2s+3)$, determine K for a) $\zeta = 0.7$ and b) range of K for underdamped closed loop system. OR A unity feedback system having closed-loop transfer function $\omega_n^2/(s^2 + 2\zeta\omega_n s + \omega_n^2)$ should have a maximum overshoot of 20% and settling time $\leq$ 2s. Determine required ω_n and ζ.	4
	b) Determine the range of values of K of a unity feedback system with $G(s) = K/s(s+1)$ so that $e_{ss} < 0.004$ when $r(t) = 0.2t$.	3
8.	For a unity feedback system with $G(s)=4/s(s+2)$, determine ξ, ω_n, ω_d, ω_g and PM theoretically. a) How much is the lead/lag compensation required to achieve PM $\geq 50°$? b) (i) Determine the amount of lead/lag compensation required if the system is desired to have ω_n=4 rad/s for the same ξ. (ii) Draw a passive RC circuit to provide the suitable angle compensation and state values of elements. OR	4+1+1+2
	Design a lead compensator for a type 1 unity feedback system with $G(s)=K/s(s+1)$. For this, a) sketch the Bode plot and determine ω_g and PM, b) determine system gain and phase compensation needed, c) determine corresponding α and new ω_g, and τ and d) lead compensator TF and overall compensated system TF.	3+2+2+1