Ref. No.Ex/IEBE/T/226/2018

B.I.E.E.2ndYr. 2nd Semester Examination, 2018

SUBJECT: Linear Control Systems

Time: Three hours

Full Marks 100

All Modules are Compulsory.

Q.No.		Marks
	Module I	
1.	Draw the signal flow graph for the system described by: $a_{11}x_1+a_{12}x_2+r_1=x_1$; $a_{21}x_1+a_{22}x_2+r_2=x_2$. Derive the relations for x_1 and x_2 using Mason's gain formula.	4
2.	Show that a feedback system is highly sensitive to parameter variations in the feedback element.	2
3.	Derive the transfer function for the system in Fig.1 using block diagram reduction technique. Draw the equivalent signal flow graph and use Mason's Gain Formula to find the transfer function.	5+4+5

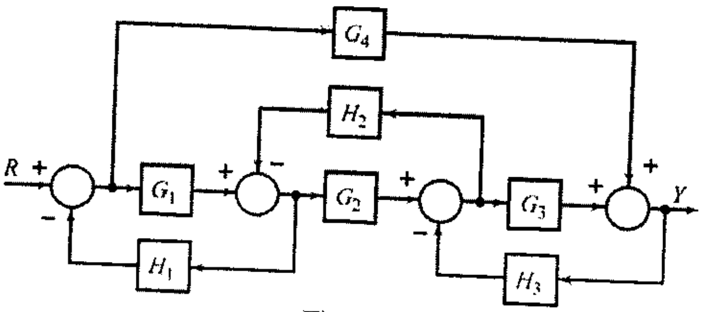

Fig.1

OR

	a) Derive the system model of a hydraulic actuator or a two stage liquid level system from first principles. Identify and explain the equivalent electrical parameters.	6
	b) An armature controlled DC servomotor driving a system has the following components: i) Potentiometer: K_e=0.5V/deg, ii) Error amplifier: K_1=10.0V/V, iii) Motor: $R_a=10.0\Omega$, L_a=0, Torque constant K_T=1Nm/A, J_m=2kgm^2, D_m=0 (including back emf effect) iv) Gear and Load: n=0.1, J_L=0.1kgm^2, D_L=0.2Nm/rad/s. Draw system block diagram and determine T.F. $\theta_o(s)/\theta_i(s)$.	8

Q.No.		Marks
	Module 2	
4.	For a 1^{st} order system $Y(s)/R(s) = K/(Ts+1)$, determine and draw the responses to the inputs: a) step of strength A, b) ramp function of slope A. Identify transient and steady state components in each case.	10
	OR	
	a) For a unity feedback system with $G(s)= 20/ (s^2+5s+5)$, find ω_n, ξ, ω_d, t_r, t_p, M_p and t_s.	6
	b) For $G(s)H(s)=K/s^2(s+1)(s+2)$, identify type of system. Find K such that the error is limited to 0.8 for an input $1+8t+5t^2$.	4
5.	A unity feedback control system has a forward path controller $G_c(s) = (s+a)/s$ preceding the process $G(s) = K (s+3)/(s^2-1)$. Find the steady state error to unit ramp input. Find conditions on a and K for system to be stable. Also find sensitivity of the system to parameter variations in a, K and the unstable open loop pole location.	10
	OR	
	For the system in Fig.2, determine a)peak overshoot for unit step input in absence of rate feedback for $K_A=1$, b) steady state error for unit ramp input for $K_A=1$, c)value of α which reduces peak overshoot for unit step input to 1.5%, d)corresponding steady state error for unit ramp input, e) K_A for which peak overshoot is 1.5% while steady state error for unit ramp input is same as in b).	10

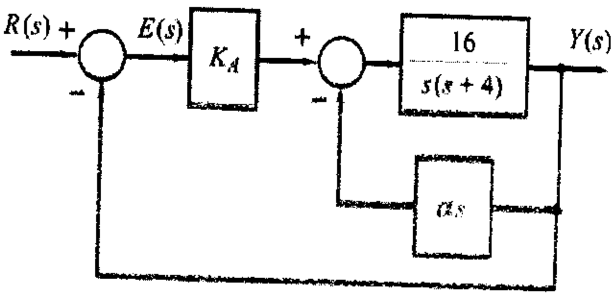

Fig.2

Q.No.		Marks
6.	**Module 3** a) For the open loop system $G(s)=K(s+1)/s(s-1)$, show that the root loci for the complex roots is a circle with center at (-1,0) and radius $\sqrt{2}$.	4
	b) Draw the Nyquist path for $GH(s)=K/s(s^2+\omega_1^2)(s+a)$, a>0 and state the representations for s in each segment with justification.	2
	c) Show the representation of gain and phase margins in Bode plots and polar plots.	4
	OR The system with characteristic equation s3+(4+K)s2+6s+16+8K=0 is designed to give satisfactory performance when a particular amplifier gain is K=2. Draw the root locus. Determine critical K, range of K for stable operation and the gain margin at K=2.	10
7.	For the system having open loop TF $GH(s) = 160(s+1)/s^2(s^2+4s+16)$, i. Identify Bode components and state magnitude and phase characteristics of the components, identify critical frequencies. ii. Draw the Bode magnitude and phase plots using asymptotes, iii. Provide table for calculated and graphically obtained gain and phase values at critical frequencies. iv. Identify gain margin, phase margin in the plots and compare graphical gain and phase margins with theoretical values. v. Comment on system stability.	4+8+4+3+1
	OR a) For the open loop T.F. $GH(s) = K/s(s+a)$ with K being a positive constant and i)a= (+1), ii)a= (-1). Draw the complete Nyquist plots. Determine and discuss the closed loop stabilities in the two cases.	10
	b) Let the open loop T.F. be $GH(s) = K(s+2)/(s+1)(s-1)$. Draw the Nyquist plot and determine the values of gain K for which the closed loop system is stable. Validate using the Routh Hurwitz table.	10

Q.No.		Marks
	Module 4	
8.	Derive the expressions for the M and N circles. For M = infinity, 1 and 0, determine the intercept on the real axis, center and radius of M-circles.	2+2+6
	OR	
	a) Determine the value of controller gains K_p and K_I for a forward path PI controller (K_p+ K_I/s) for a unity feedback system with G(s) = 2/(s+4) so that its damping ratio and natural frequency of oscillation become 1 and 4 Hz resp.	6
	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.	4
9.	A system has an open loop transfer function GH(s) = $K/(s+2)^2(s+4)$. i) Draw the root locus of the system with K as variable. ii) Determine the value of the critical gain for the system and the frequency at which this occurs. iii) Obtain the value of K for which $K_p \geq 2$. iv) Also find the value of K for which gain margin ≥ 3. v) Identify range of K for which $K_p \geq 2$ and gain margin ≥ 3	20
	OR	
	Design a lead compensator for a unity feedback system with an open loop transfer function G(s) = K/{s(0.1s+1) (0.001s+1)} for the specifications of K_v=1000s^{-1} and phase margin $\varphi_m \geq 45°$.	20