B.I.E.E. 2ndYr. 2nd Semester Examination, 2019 SUBJECT: Linear Control Systems

Time: Three hours

Full Marks 100

Q.No.	All Modules are Compulsory.	iviarks 100
×10.		Marks
1.	Draw the schematic diagram and derive the system equations for a) DC field controlled motor, b) Pneumatic system and c) Accelerometer.	6
	OR Draw and describe a simple thermally insulated system with heater and stirrer. Identify system parameters and derive their mathematical model. Derive the 2 input single output unity feedback loop representation of the system considering temperature as output and inflow rate and inlet temperature as the inputs.	
2.	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
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	Fig.1 OR	
	a) Draw and describe an AC position servo system and derive the control equation for the error signal. Draw the waveforms for carrier, reference and measured angular displacements, error and output signals stating	6
	assumptions and justifications. b) An armature controlled DC servomotor driving a system has the following components:	8
	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: $n=0.1$, $J_T=0.1kgm^2$	
	D _L =0.2Nm/rad/s. Draw system block diagram and determine T.F. $\theta_0(s)/\theta_1(s)$.	&

	Q.No.		
j	3.	Modul a	Marks
	<i>3.</i>	Derive and draw the unit step response for a 2^{nd} order underdamped system from first principles. Derive the initial value, the transient response, the envelopes and their start values, t_p , M_p , and t_s and show these in the diagram.	
		 a) For a unity feedback system with G(s)=25/s(s+6), determine the closed loop T(s), ξ, ω_n, ω_d, t_r, t_s, t_p and M_p. For a unit ramp input, determine the steady state error. b) For G(s)H(s)=K/s²(s+1)(s+2), identify type of system. Find K such that the error is limited to 0.8 for an input 1+8t+5t². 	6
	1.	A unity feedback control system has a forward path agent in	10
		For the system in Fig.2, determine a) peak overshoot for	10
		$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	
5.	Dra	Fig.2 Module 3 aw the root contours of the system with $GH(s)=K/s(s+1)(s+\alpha)$.	
6.	Dra	where the root locus of $GH(s)=Ks/(s^2+4)(s^2+16)$.	
		For a unity feedback system with $GH(s)=K(s+2)/(s^2+2s+3)$, determine the open loop poles and show that the root loci from the poles are circular. What is the system gain and corresponding to for which $\xi=0.7$?	
	b) c) 1	Draw the asymptotic Bode magnitude and phase plot for a simple pole 1/(1+j\omegaT). Identify the critical frequency. Provide the derivation of the asymptotic segments and derive the values of errors at twice and ten times the critical frequency. Determine the breakaway points for the provide the present	
	- Control of the Control	$G(s)=K/s(s+4(s^2+4s+20))$.	

OR For the system having open loop TF GH(s) = 160(s+1)/s³(s³+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. 7. a) Draw the Nyquist contour and Nyquist plot of G(s)=1/s(sT+1). What is the real intercept at ω=0? b) State the expressions for GM and PM. Illustrate ω _p , ω _g , GM and PM in notional Bode magnitude and phase plots. Show how GM and PM are identified in a log magnitude vs. phase plot. c) How to determine the ω at which PM is +90° using N circles? OR a) Draw the Nyquist contour and Nyquist plot of G(s) = 10(s+3)/s(s-1), b) Show and explain how GM and PM can be identified using a phase plot. c) Derive from first principles the relation for M circles in terms of the real and imaginary parts of G(jω). Module 4 For a mass spring damper system subjected to 2N force, the steady state displacement of the mass required is 0.1m and the peak overshoot at 2s is required to be 0.0015m. Determine M, f and K of the system. OR a) Determine the value of controller gains K _p and K ₁ for a forward path PI controller (K _p + K ₁ /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. 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. A unity feedback system with controller gain 5 and a velocity feedback des, in the forward path. Draw the system block diagrams and determine.	Q.No.		Marks
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		in the lower paul. Draw the system block diagrams and determine 1	
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ω=5rad/s, determine the system gain K and the sensitivity to gain at the operating frequency.		the operating frequency	
OR			
Design a lead compensator for a unity feedback system with an open			
loop transfer function $G(s) = 4K/\{s(s+2)\}\$ for the specifications of		loop transfer function $G(s) = 4K/(s(s+2))$ for the proofing the state of	7
$K_{\nu}=20s^{-1}$, phase margin $\phi_{m} \ge 50^{\circ}$ and gain margin at least 10dB.		K _v =20s ⁻¹ , phase margin $\omega_v > 50^\circ$ and gain margin at least 10.4B	