Ref. No.Ex/PG/IEE/T/1210A/2019

M.Tech (I.E.E.) 1st Yr. 2nd Semester Examination, 2019

SUBJECT: Dynamic System Control and Optimization

Time: Three hours

Full Marks 100

Answer *any* five. All questions carry equal marks.

Q.No.		Marks
1.	Write short notes on: (*any* four) a) State space model of a Position Servo System b) State space model of a Mixing Tank c) Effect of sampling on controllability and observability d) Deadbeat control e) Hamilton Jacobi Equation f) Luenberger full order state observer g) Discrete Algebraic Riccati Equation h) Separation principle i) Linear quadratic regulator j) Pontryagin's minimum principle	5x4=20
2.	a) For a system described by $\dot{x}(t) = Ax(t) + Bu(t);\ y(t) = Cx(t)$, $A = \begin{bmatrix} -1 & 0 \\ 0 & -2 \end{bmatrix};\ B = \begin{bmatrix} 1 \\ 1 \end{bmatrix};\ C = [1 \quad 1];$ Find a) i) $\Phi(t,\tau)$, ii)controllability Grammian, iii) control u(t) which drives the system from rest x(0)=0 to $x(1)=[1 \ \ 1]^T$ in 2s b)state x(0) when y(t)=0.5 exp(-2t)+1.5 for u(t)=1, $t \geq 0$.	8
	b) Comment on the controllability of the discrete time system with $F = \begin{bmatrix} 1 & k \\ 0 & -1 \end{bmatrix},\ g = \begin{bmatrix} 2 \\ k \end{bmatrix}$ when k=0. If the system is controllable, then find a control sequence to the drive the system from x(0)= $[0\ 0]^T$ to $x(1)=[1\ 1]^T$.	6
	c) For the system $x(k+1) = \begin{bmatrix} -2 & -1 \\ -1 & -2 \end{bmatrix} x(k) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(k);\ y(k) = [1 \quad -1] x(k)$ find i)control sequence {u(0),u(1)} to drive the system from $x(0)^T = [1 \quad 0]$ to $x(2)^T = [-1 \quad 0]$, ii) the state x(0) when y(0)=1, y(1)=0, y(2)=-1, y(3)=2 for $u(k)=(-1)^k$, $k \geq 0$.	6

Q.No.		Marks
3.	a) Find state models for the following: i) $\frac{d^3y}{dt^3}+6\frac{d^2y}{dt^2}+11\frac{dy}{dt}+6y=u$ ii) $y(k+3)+5y(k+2)+7y(k+1)+3y(k)=u(k+1)+2u(k)$	10
	b) Obtain a controllable companion form representation and initial condition vector of the differential equation $\dddot{y}+6\ddot{y}+11\dot{y}+6y=\dot{u}+4u$.	5
	c) Find the Jordan canonical realization of $\frac{s^3+8s^2+17s+8}{s^3+6s^2+11s+6}$ and draw the state diagram.	5
4.	a) State and prove Lyapunov stability theorem (direct method) for linear continuous time autonomous systems. Illustrate the notion of energy function V for different conditions of stability/ instability.	5+5=10
	b) Find the Lyapunov matrix P that ensures asymptotic stability of the system $A=\begin{bmatrix}-1 & -2\\ 1 & -4\end{bmatrix}$ for Q=I. Determine the upper bound on the time it takes this system to go from the initial state x(0)=[1 0]T to within the maximal surface V(x)=K=0.009.	10
5.	a) For a unity feedback system with plant transfer function G(s) = K/{s(s+2)}, obtain the state space model and infer the condition for stability in terms of the gain K using Routh Hurwitz criterion.	5
	b) Obtain the corresponding discrete-time system matrices F(k), G(k) for the plant in a). Let a sampler and ZOH be introduced in the forward control path before the plant. Obtain the discrete-time state space description for this closed loop sampled data system in terms of x(k+1).	7
	c) Find the system characteristic equation for the sampled-data system and infer the stability when i) T=0.4s and ii)T=3s.	2+3+3

Q.No.		Marks
6.	a) Formulate the two point boundary value problem which when solved, yields the optimal control u*(t) for the system $\dot{x}_1 = x_2; \dot{x}_2 = x_1 + (1 - x_1^2)x_2 + u$; where $x(0) = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$, and the performance index $J = \frac{1}{2}\int_0^2 (2x_1^2 + x_2^2 + u^2)\, dt$ when (i) u(t) is not bounded and (ii) $\|u(t)\| \le 1$.	10
	b) Find the optimal control $u^*(t)$ for the system $\dot{x}(t) = 2x(t) + u(t)$; which minimizes the performance index $J = \frac{1}{2}\int_0^{t_1} (3x^2 + \frac{1}{4}u^2)\, dt$, where t_1 is specified.	10
7.	a) Design a feedback controller with state feedback for a linear system described by the system matrices $A = \begin{bmatrix} 0 & 1 & 0 \\ 3 & 2 & 0 \\ 1 & 1 & 1 \end{bmatrix}; B = \begin{bmatrix} 0 & 0 \\ 1 & 0 \\ 0 & 1 \end{bmatrix}; C = \begin{bmatrix} 1 & 2 & 0 \\ 0 & 0 & 1 \end{bmatrix}$ so that the eigenvalues of the closed loop system are at -1,-2, -3.	10
	b) For a position servo system described by $F = \begin{bmatrix} 1 & 0.0787 \\ 0 & -.6065 \end{bmatrix}, g = \begin{bmatrix} 0.0043 \\ 0.0787 \end{bmatrix}$, determine a deadbeat control law. Further, assuming that only the angular position measurement is available, design a deadbeat observer for the system.	5+5=10