Ref. No.Ex/PG/IEE/T/1210A/2018

M.Tech (I.E.E.) 2nd Semester Examination, 2018

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 Power System b) State space model of an Nuclear Reactor c) State equation for Sampled Data System d) Controllability and Observability in Continuous Time Systems e) Existence and Uniqueness of solutions to Continuous-time state equations f) Deadbeat Control g) Hamilton Jacobi Equation h) Luenberger full order state observer i) Separation principle j) Discrete-time Linear state regulator	5x4=20
2.	a) For a system described by $\dot{x}(t) = Ax(t) + Bu(t);\ y(t) = Cx(t)$, $A = \begin{bmatrix} 1 & e^{-t} \\ 0 & -1 \end{bmatrix};\ B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}; C = [1 \quad 1]$, find i) $\Phi(t,\tau)$, ii)controllability Grammian, iii) minimum energy control $u^*(t)$ which drives the system from rest $x(0)=0$ to $x(1)=[1 \quad 1]^T$ in 1s and iv) corresponding $x^*(t)$, $t \geq 0$.	8
	b) Comment on the observability of the discrete time system with $F = \begin{bmatrix} 1 & k \\ 0 & -1 \end{bmatrix}, g = \begin{bmatrix} 2 \\ k \end{bmatrix}, c = \begin{bmatrix} 1 & k \end{bmatrix}$ when k=1. If the system is observable, then determine x(1) from the control sequence $u(k)=(-1)^k$; $k \geq 1$; and the measurements: y(1) =3, y(2)=-5.	6
	c) For a system described by $\dot{x}(t) = Ax(t) + Bu(t)$, where $A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$; $B = \begin{bmatrix} b_1 \\ b_2 \end{bmatrix}, x(0) = x^0$, the eigenvalues of the matrix A are -1 and -2. Find a) the eigenvectors, b) the homogeneous solution and c) the non-homogeneous solution. Determine conditions on b_1 and b_2 for suppression of the two modes individually.	6

Q.No.		Marks
3.	a) Find state models for the following: i) $\frac{d^3y}{dt^3}+3\frac{d^2y}{dt^2}+2\frac{dy}{dt}=\frac{du}{dt}+u$ ii) $y(k+2)+3y(k+1)+2y(k)=5u(k+1)+3u(k)$	8
	b) Obtain a controllable companion form representation of the differential equation $\dddot{y}+6\ddot{y}+11\dot{y}+6y=\dot{u}+u$. Is this system observable? If yes, find the initial state vector. If no, then find the initial state vector for a reducible form of this system.	3+4
	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) Illustrate the notion of energy function V for different conditions of stability/ instability.	5
	b) Discuss the use of Lyapunov functions to estimate transients.	5
	c) For the system $A=\begin{bmatrix}0 & 1\\ -1 & -1\end{bmatrix}$, find a suitable Lyapunov function V(x). Obtain the upper bound on the response time such that it takes the system to go from a point on the boundary of the closed curve V(x)=100 to a point within the closed curve V(x)=0.05.	10
5.	a) For a unity feedback system with plant transfer function G(s) = 5/{s(s+1)(s+2)}, determine the stability of the unity feedback closed loop system 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. For this closed loop sampled data system, determine the stability for this closed loop system for T=1s.	3+4
	c) Find the Lyapunov function V(x) that ensures asymptotic stability of the system $A=\begin{bmatrix}0 & 1\\ -2 & -3\end{bmatrix}$. Determine the upper bound on the time it takes this system to go from the initial state x(0)=[1 1]^T to within the area defined by $x_1^2+x_2^2=0.1$.	2+3+3

Q.No.		Marks
6.	a) Formulate the two point boundary value problem and obtain the optimal control u*(t) for the system $\dot{x}_1 = x_2$; $\dot{x}_2 = x_2 + u$; where the performance index $J = \frac{1}{2}\int_0^2 (x_1^2 + u^2)\, dt$ when (i) only $\lvert u(t)\rvert \le 1$. and when (ii) $-1 \le x_1(t) \le 2$. and $\lvert u(t)\rvert \le 1$.	10
	b) Find the optimal control $u^*(t)$ for the linear quadratic regulator $\dot{x}(t) = 2x(t) + u(t)$; 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