SRM VALLIAMMAI ENGINEERING COLLEGE

SRM Nagar, Kattankulathur – 603 203.

DEPARTMENT OF

ELECTRICAL AND ELECTRONICS ENGINEERING

QUESTION BANK

BE-Electrical and Electronics Engineering

IIIrd Year SEMESTER VI

1905604-ADVANCED CONTROL SYSTEM

Regulation–2019

Academic Year 2024–25(EVEN)

Prepared by

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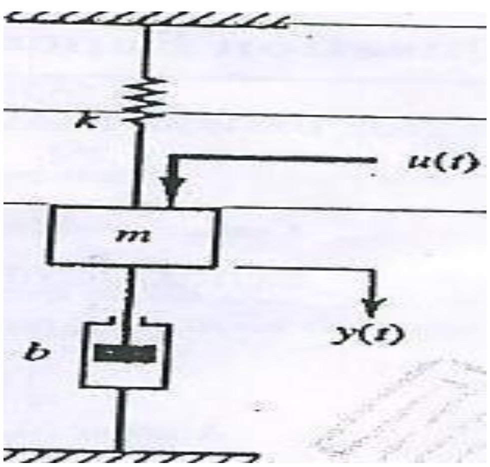
UNIT I STATE VARIABLE ANALYSIS			
Introduction- concepts of state variables and state model-State model for linear continuous time systems, Diagonalisation- solution of state equations- Concepts of controllability and observability.			
PART A			
Q.No.	**Questions**	**BTL Level**	**Domain**
1.	Examine the general form of the state space model for continuous system. And also write the state diagram.	BTL 5	Evaluating
2.	Define the following terms such as (i) State (ii) State Variable (iii) State Vector (iv) State Space Model.	BTL 1	Remembering
3.	Give any two approach to convert the transfer function approach to the state space model.	BTL 1	Remembering
4.	What is the state transition matrix ? List any two methods for finding state transition matrix.	BTL 1	Remembering
5.	Quote the formula for the solution of the state equation in time domain?	BTL 1	Remembering
6.	Evaluate the general form of state space model for continuous system.	BTL 5	Evaluating
7.	What is state transition matrix and identify how it is related to state of a system?	BTL 2	Understanding
8.	Illustrate the concept of Diagonalization of the matrix.	BTL 3	Applying
9.	Examine How the state transition matrix e^{At} is computed by canonical transformation.	BTL 2	Understanding

10.	What is meant by duality of the system. Develop the expression by Kalman's Method.	BTL 2	Understanding
11.	Obtain the state space model for the given differential equation solve and obtain the transfer function model $\frac{d^3Y}{dt^2}+6\frac{d^2Y}{dt^2}+11\frac{dY}{dt}+6Y=U(t)$	BTL 3	Applying
12.	Consider a system whose transfer function is given by Y(S)/U(S) = 10(S+1)/$S^3+6s^2+5s+10$. Calculate state model for this system.	BTL 3	Applying
13.	A discrete time system is described by the difference equation Y(K+2)+5Y(K+1)+6Y(K) =U(K).Solve and find the transfer function of the system.	BTL 3	Applying
14.	State the condition for observability by kalman's method.	BTL 1	Remembering
15.	Derive and explain the transfer function model of a LTI system whose state equation is given by $\dot{X}=\begin{pmatrix}1 & 2\\ 1 & 1\end{pmatrix}X+\begin{pmatrix}1\\ -1\end{pmatrix}U$ $Y=\begin{pmatrix}1 & 1\end{pmatrix}X$	BTL 4	Analyzing
16.	Explain the solution of homogeneous state equations.	BTL 4	Analyzing
17.	Formulate the state transition matrix by Matrix Exponential method $A=\begin{bmatrix}-1 & 1\\ 0 & -1\end{bmatrix}$	BTL 5	Evaluating
18.	Judge any 2-methods for the conversion of transfer functional model into state space model.	BTL 5	Evaluating
19.	Define the duality of the system between controllability and observability concept?	BTL 1	Remembering

20.	The given state space model $$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix}=\begin{bmatrix}-2 & 1 & 0\\ 0 & -2 & 0\\ 0 & 0 & -3\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}+\begin{bmatrix}0\\ 4\\ 5\end{bmatrix}U\ ;\ y=[1\ 0\ 0]\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}$$ Examine whether the given is controllable.	BTL 5	Evaluating
21.	Examine the need for Controllability test and observability test?	BTL 5	Evaluating
22.	Evaluate the condition for controllability and observability by Gilbert's method.	BTL 5	Evaluating
23.	Formulate the condition for controllability and observability by Kalman's method	BTL 6	Creating
24.	Analyze how the state transition matrix e^{At} is computed using Cayley- Hamilton theorem?	BTL 4	Analyzing
PART – B			
1.	Evaluate the state space model for the mechanical system as shown in Fig.. Where u(t) is input and y(t) is output. Also derive the transfer function from the state space equations.  (13)	BTL 5	Evaluating
2.	Design explain (i) Armature control of DC Motor (ii) Field Control of DC Motor. And also draw the (i) Block diagram (ii) State diagram and state space model for the system. (13)	BTL 6	Creating

3.	The given state space model $\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix}=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -6 & -11 & -6\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}+\begin{bmatrix}0\\ 0\\ 3\end{bmatrix}U$;y=[1 0 0] $\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}$ Check whether the given is controllable and observable or not. And also Point out the duality by Kalman's approach and Gilbert's method. (13)	BTL 4	Analyzing
4.	The given state space model $\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix}=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ 0 & -2 & -3\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}+\begin{bmatrix}0\\ 0\\ 1\end{bmatrix}U$; y=[3 4 1] $\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}$ Check whether the given is controllable and observable or not. And also Point out the duality by Kalman's approach. (13)	BTL 4	Analyzing
5.	Illustrate the expression for the state space model for the continuous system and also draw the state diagram for it. (13)	BTL3	Applying
6.	Illustrate the expression for the Controllability and Observability in (i) Kalman's Method (ii)Gilbert's Method. (13)	BTL3	Applying
7.	Solve the state space model for the given system(i) Y(S)/U(S)=10/S^3+4S^2+2S+1 by the method of (i) Laplace Transform (ii) Signal Flow Graph Method. (13)	BTL 3	Applying
8.	Evaluate the state space model for the given differential equation $\frac{d^3Y}{dt^2}+6\frac{d^2Y}{dt^2}+11\frac{dY}{dt}+6Y=U(t)$ by Canonical form or companion form method and also draw the state diagram for it. (13)	BTL 5	Evaluating
9.	Formulate the state transition matrix by (i) Matrix Exponential Method (ii)Laplace Transform method. (13) $A=\begin{bmatrix}0 & 5\\ -1 & -2\end{bmatrix}$	BTL 6	Creating

10.	Evaluate the value of e^{At} by (i) Trial and Error Method (ii) Cayley Hamilton's Theorem. $A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$ (13)	BTL 1	Remembering
11.	Analyze the value of state transition matrix or e^{At} by using (a) Laplace Transform Method (b) Cayley Hamilton's Theorem (c)A^{10} in which $A = \begin{bmatrix} 0 & 1 \\ -12 & 7 \end{bmatrix}$ (13)	BTL 3	Applying
12.	The given matrix $A = \begin{bmatrix} -1 & 1 & 1 \\ 0 & -1 & 1 \\ 0 & 0 & --1 \end{bmatrix}$; Calculate the state transition matrix by using Laplace transform method. (13)	BTL 3	Applying
13.	Analyze the value of state transition matrix or e^{At} by using (a) Laplace Transform Method (b) Cayley Hamilton's Theorem $A = \begin{bmatrix} 0 & 1 \\ -6 & -5 \end{bmatrix}$;B=[1;1]with initial condition=[1;2] (13)	BTL 3	Applying
14.	Create the state space model by using signal flow graph for the given problem(i)Y(S)/U(S)=10/(S^3+5S^2+4S+10) (13)	BTL 6	Creating
15.	Illustrate the expression by (i) Matrix Exponential Method (ii) Laplace Transform Method for state transition of matrix. (13)	BTL 3	Applying
16.	Obtain the state space Model $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 4 \end{bmatrix} U$; y=[1 0 0] $\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$ Convert the state space model into canonical form state space model. And also calculate the value of state transition matrix. (13)	BTL 5	Evaluating

17.	The given state space model $$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix}=\begin{bmatrix}0 & 1 & 1\\ 0 & 0 & 1\\ -1 & -5 & -6\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}+\begin{bmatrix}0\\ 0\\ 10\end{bmatrix}U \text{ ; } y=[1\ 0\ 0]\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}$$ Check and discuss whether the given is controllable and observable or not. And check the duality by Kalman's approach and Gilbert's method. (13)	BTL 5	Evaluating
PART C			
1.	Create the expression for the following Methods for State Transition Matrix as follows (i) Trial and Error Method (iii) Laplace Transform Method (iv) Canonical Form. (15)	BTL 6	Creating
2.	The transfer function of the system $Y(S)/U(S)=3/S^3+6S^2+11S+6$. Check and express whether the system is controllable as well as observable. And check the duality by Kalman's approach and Gilbert's method. (15)	BTL 4	Analyzing
3.	With the case study Summarize (i) Armature control of DC Motor (ii) Field Control of DC Motor. And also draw the (i) Block diagram (ii) State diagram and state space model for the system. (15)	BTL 5	Evaluating
4.	The given state space model $$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix}=\begin{bmatrix}-2 & 1 & 0\\ 0 & -2 & 0\\ 0 & 0 & -3\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}+\begin{bmatrix}0\\ 4\\ 5\end{bmatrix}U \text{ ; } y=[1\ 0\ 0]\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}$$ Solve whether the given is controllability and observability. (15)	BTL 4	Analyzing
5.	(i) Consider a system whose transfer function is given by $Y(S)/U(S) = 10(S+1)/S^3+6s^2+5s+10$. Solve the state model for this system. (7)	BTL 3	Applying

	(ii) The given state space model $\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix}=\begin{bmatrix}-5 & 1 & 1\\ -1 & 0 & 1\\ 0 & 0 & 1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}+\begin{bmatrix}0\\ 4\\ 5\end{bmatrix}U$; y=[1 0 0] $\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}$ Point out whether the given is controllable or observable or not. Also check the duality principle. (8)	BTL 4	Analyzing

UNIT II STATE VARIABLE DESIGN			
Introduction to state model: Effect of state feedback - Pole placement design: Necessary and sufficient condition for arbitrary pole placement, State regulator design Design of state observers- Separation principle- Design of servo systems: State feedback with integral control.			
PART A			
Q.No.	**Questions**	**BTL Level**	**Domain**
1.	What is the state observer? Draw the diagram for State Observer and point out main features.	BTL 1	Remembering
2.	Analyze the need for state observer for the system?	BTL 1	Remembering
3.	Summarize the following terms (i) Full-order observer (ii) Reduced-order observer (iii) Minimum-order state observer?	BTL 1	Remembering
4.	What is the necessary condition to be satisfied for the design of state observer?	BTL 1	Remembering
5.	Define the term Pole Placement of controller.	BTL 1	Remembering
6.	Formulate the Ackermann's formula to find the state feedback gain matrix, K.	BTL 1	Remembering
7.	What is meant by pole placement of controller ?	BTL 2	Understanding
8.	Illustrate the general form of observable phase variable form of state model.	BTL 2	Understanding

9.	Summarize the pole placement controller by state feedback?	BTL 2	Understanding
10.	How will you Evaluate the transformation matrix, P_o to the state model to observable phase variable form?	BTL 2	Understanding
11.	How control system design is carried in state space and discuss with an suitable example.	BTL 3	Applying
12.	Quote the necessary condition to be satisfied for design using state feedback?	BTL 3	Applying
13.	Illustrate the block diagram of a system with state feedback concept for controller.	BTL 3	Applying
14.	Express the general form of controllable phase variable form of state model approach.	BTL 4	Analyzing
15.	What is meant by Control law?	BTL 4	Analyzing
16.	Illustrate how will you find the transformation matrix, Pc to transform the state model to controllable phase variable form using the characteristic equation?	BTL 3	Applying
17.	Sketch the diagram of full order observer for linear system.	BTL 3	Applying
18.	Write the Ackermann's formula to identify the state observer gain matrix, G.	BTL 5	Evaluating
19.	What is the necessary condition to be satisfied for the design of state observer.	BTL 6	Creating
20.	Write the observable phase variable form of state space model.	BTL 6	Creating
21.	Draw the block diagram of Full order observer for state feed back system.	BTL 5	Evaluating
22.	Draw the block diagram of a system with state feedback.	BTL 5	Evaluating

23.	Draw the block diagram of reduced order observer for state feed back system	BTL 6	Creating
24.	What is the effect of pole zero cancellation in transfer function ?	BTL 6	Creating
	PART – B		
1.	Consider a system with state space model is given below. $$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix}=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -6 & -11 & -6\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}+\begin{bmatrix}0\\ 0\\ 1\end{bmatrix}U\ ;\ y=[1\ \ 0\ \ 0]\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}$$ Point out that the system is observable. The design of a state observer desired eigen values. Find the value of observable gain G. (13)	BTL 3	Applying
2.	Consider the state space model described by $\dot{X}(t)=AX(t)$, $Y(t)=CX(t)$; $A=\begin{bmatrix}-1 & 1\\ -1 & -2\end{bmatrix}$; C=[1 0]. Design and examine a full-order state observer. The desired Eigen values for the observer matrix $\mu_1=-5; \mu_2=-5$. (13)	BTL 3	Applying
3.	What is meant by pole placement of controller ? derive the expression for pole placement of controller ? (13)	BTL 4	Analyzing
4.	Obtain and analyze the expression for (i) Full order observer (ii) Reduced Order Observer (iii) Pole Placement of Controller. (13)	BTL 5	Evaluating
5.	Describe the effect of feedback on the concept of Controllability and Observability of the system. (13)	BTL 3	Applying

6.	Describe in detail the concept of state space model for full order observer and reduced order observer. (13)	BTL 5	Evaluating
7.	Derive the expression for the state observer gain for the state space model. (13)	BTL 4	Analyzing
8.	Derive the expression the state space model for the linear continuous system. (13)	BTL 3	Applying
9.	What is meant by state observer ? Draw and analyze the state diagram and explain with an example for state space with feed back (i) Full Order (ii) Reduced Order Observer. (13)	BTL 2	Understanding
10.	Consider a system with state space model is given below. $$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 1 & 2 & 0 \\ 3 & -1 & 1 \\ 0 & 2 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 2 \\ 1 \\ 1 \end{bmatrix} U \text{ ; } y=[\,0\ \ 0\ \ 1\,] \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$ Point out that the system is observable. The design of a state observer so the eigen values of the matrix at -4,-3+i,-3-i. Find the value of observable gain G. (13)	BTL 3	Applying
11.	Illustrate the effect of state feedback gain by pole placement(i) Open loop state space without feedback gain (ii) Closed loop state feedback gain with control law for obtaining gain K by any one of the method with necessary condition. (13)	BTL 3	Applying
12.	Derive the expression of (i) State Space Model (ii) Pole Placement of Controller. (13)	BTL 4	Analyzing
13.	What is meant by observer ? How the observer concept related with Observability. Examine the following types of observer (i) Full Order Observer (ii) Reduced Order Observer. (13)	BTL 5	Evaluating

14.	Consider a linear system described by the transfer function Y(S)/U(S)=10/S(S+1)(S+2). Design a feed back controller with a state feedback so that the closed loop poles are placed at -2,-1+j, -1-j. (13)	BTL 6	Creating
15	Illustrate the following type of observer with suitable diagram and mathematical expression : (i) Full Order Observer (7) (ii) Reduced Order Observer (6)	BTL 3	Applying
16	Derive the expression for the control system design via pole placement by state feedback. (13)	BTL 4	Analyzing
17	Consider a system with state space model is given below. $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -5 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} U$; y=[1 0 0] $\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$ Point out that the system is controllable. The desired poles are S=-2+j4, -2-j4 ,-10 with state feedback control U=-Kx . Find the state feedback gain matrix K. (13)	BTL 5	Evaluating

PART – C

1	What is meant by pole placement of controller ? derive the expression for pole placement of controller ? (15)	BTL 3	Applying
2	Consider the state space model described by $\dot{X}(t) = AX(t)$; $Y(t) = CX(t)$ $A = \begin{bmatrix} 0 & 20.6 \\ 1 & 0 \end{bmatrix}$, B=[0;1]; C=[0 1]. Design and examine a full-order state observer. The desired Eigen values for the observer matrix $\mu_1 = -1.8 + j2.4; \mu_2 = -1.8 - j2.4$. (15)	BTL 4	Analyzing

3	Consider a system with state space model is given below. $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 1 & 2 & 0 \\ 3 & -1 & 1 \\ 0 & 2 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 2 \\ 1 \\ 1 \end{bmatrix} U$; y=[0 0 1] $\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$ Design a Full order obser the system. The design of a state observer so the eigen values of the matrix at -4,-3+i,-3-i. Find the value of observable gain G. (15)	BTL 5	Evaluating
4	Consider a system with state space model is given below. $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} -1 & 0 & 0 \\ 1 & -2 & 0 \\ 2 & 1 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 10 \\ 1 \\ 0 \end{bmatrix} U$; y=[1 0 0] $\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$ Point out that the system is controllable. The desired poles are S=-1+j2, -1-j2 ,-6 with state feedback control U=-Kx . Find the state feedback gain matrix K. (15)	BTL 4	Analyzing
5	What is meant by state observer ? Draw the block diagram of Full Order Observer, Derive the expression and obtain the State observer Gain G. (15)	BTL 3	Applying

UNIT III SAMPLED DATA ANALYSIS

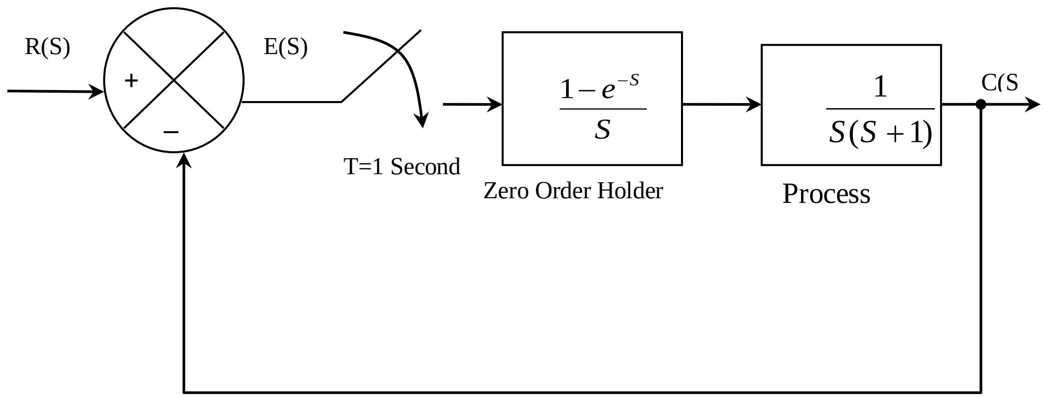
Introduction to sampling theorem spectrum analysis of sampling process signal reconstruction difference equations The Z-transform function, the inverse Z transform function, response of Linear discrete system, the Z-transform analysis of sampled data control systems, response between sampling instants, the Z and S domain relationship. Stability analysis-Jury's test, Bilinear transform and compensation techniques.

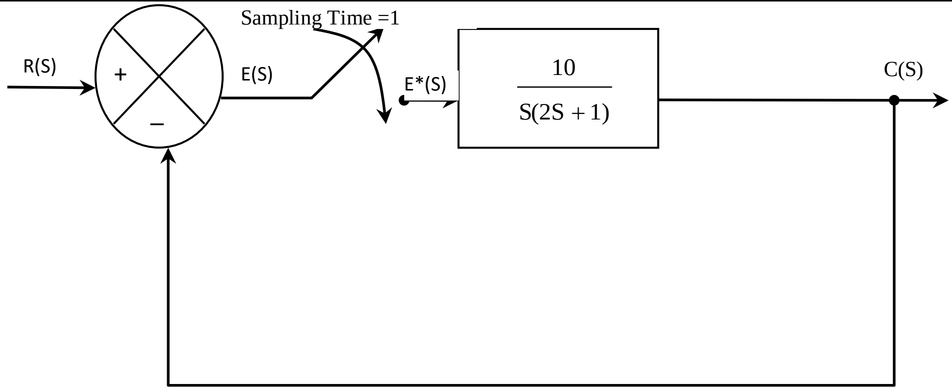
PART A

Q.No.	Questions	BTL Level	Domain

1.	What is sampled data control system ?	BTL 1	Remembering
2.	State Shanon's sampling theorem.	BTL 1	Remembering
3.	What is meant by quantization ?	BTL 1	Remembering
4.	Draw the block diagram of sampled data control system.	BTL 1	Remembering
5.	Define discrete transfer function of the system.	BTL 1	Remembering
6.	Express the terms sampler and holder.	BTL 1	Remembering
7.	Define the term Z-Transform.	BTL 1	Remembering
8.	Define one sided and two sided Z-Transform.	BTL 1	Remembering
9.	What is meant by quantization ?	BTL 2	Understanding
10.	What is meant by Holder ?	BTL 1	Remembering
11.	Mention any 2-methods to find inverse Z-Transform.	BTL 1	Remembering
12.	How the Z-Plane is related with S-Plane ?	BTL 3	Applying
13.	Find the Z-Transform (i) Impulse Input (ii) Step Input.	BTL 3	Analyzing
14.	State initial and final value theorem for Z-Transform.	BTL 3	Applying
15.	Find the Z-Transform for (i) a^k (ii) e^{-akt}.	BTL 3	Applying
16.	What is meant by Region of Convergence(ROC) ?	BTL 4	Analyzing
17.	What is holder in sampled data control system ?	BTL 5	Evaluating
18.	Express the following types of Holder (i) Zero Order Holder(ZOH) (ii) First Order Holder.	BTL 5	Evaluating
19.	What is the equivalent representation of pulse sampler with ZOH ?	BTL 6	Creating
20.	Express the condition the sampled data system to be stable.	BTL 6	Creating

21.	Mention the methods to find the stability analysis of sampled data control system.	BTL 3	Analyzing
22.	Express the necessary conditions to be satisfied for the stability analysis of sampled data control system ?	BTL 3	Applying
23.	What is bilinear transform ?	BTL 1	Remembering
24.	Mention the necessary condition for Jury's stability analysis.	BTL 1	Remembering
	PART – B		
1.	Find the Z-Transform for the input signals (i) Step Input Signal (ii) Impulse Input Signal (iii) Ramp Input Signal (iv) Parabolic Input Signal. (13)	BTL 1	Remembering
2.	Derive the Discrete Input for (i) Discrete Sinusoidal Input (ii) Discrete Sinusoidal Input. (13)	BTL 1	Remembering
3.	(i) Evaluate the z-transform and ROC of $x(n)=r^n\cos(n\theta)u(n)$ (7) (ii) Evaluate the Inverse z-transform of $X(z) = z/[3z^2-4z+1]$, ROC $\|z\|>1$, $\|z\|<1/3$, $1/3<\|z\|<1$. (6)	BTL 4	Analyzing
4.	(i) Find the Z-transform and analyze its associated ROC for the following discrete time signal $x[n] = \left[\frac{-1}{5}\right]^n u(n) + 5\left[\frac{1}{2}\right]^{-n} u(-n-1)$ (7) (ii) Explain the properties of Z-transform. (6)	BTL 4	Analyzing
5.	(i) Find x(n) by convolution for $X(z) = \frac{1}{(1-0.5z^{-1})(1+0.25z^{-1})}$ (6) (ii) Using scaling property, determine the z-transform of the sequence $x(n)=\alpha^n\cos w_0 n$ (7)	BTL 3	Applying
6.	Draw the basic block diagram of sampled data control system. Explain (i) Sampler (ii) Holder (iii) Shannon's Sampling Theorem. (13)	BTL 3	Applying
7.	Find the inverse Z-transform for the following transfer functions: (i). $F(Z) = \frac{(Z+1)}{(Z+0.2)(Z-1)}$ (ii) $.F(Z) = \frac{Z^2}{Z^2+Z+2}$ (13)	BTL 3	Applying
8.	(i)Explain the following types of Holder (i) Zero Order Holder (ii) First Order Holder. (7)	BTL 3	Applying

	(ii) How the s-plane is related with z-plane explain it. (6)		
9.	Obtain the unit step response of the system is as shown in Fig.. (13) 	BTL 3	Applying
10.	Solve the differential equation $\mathbf{Y(n+2)+3Y(n+1)+2Y(n)=U(n)}$. where $\mathbf{Y(0)=0.Y(1)=1}$ and the applied input is step. (13)	BTL 4	Analyzing
11.	Find the inverse Z-transform for the following transfer functions: (i). $\mathbf{F(Z)=\frac{Z}{3Z^2-4Z+1}}$ in which the ROC of $\mathbf{i.\lvert Z\rvert>1}$ ii. $\mathbf{\lvert Z\rvert<\frac{1}{3}}$ (7) (ii). $\mathbf{F(Z)=\frac{Z^2+Z}{Z^2-2Z+1}}$ in which the ROC of $\mathbf{i.\lvert Z\rvert>1}$ $\mathbf{ii.\lvert Z\rvert<\frac{1}{2}}$ (6)	BTL 4	Analyzing
12.	Find the inverse Z-transform for the following functions using Partial Fraction Expansion method: (i). $\mathbf{F(Z)=\frac{z^3}{(Z-2)(Z-1)^2}}$ (ii). $\mathbf{F(Z)=\frac{z^2}{z^2-Z+0.5}}$ (13)	BTL 4	Analyzing
13.	Check for stability of the sampled data control system: (i) Bilinear transform Method (ii) Jury's Test . (13)	BTL 1	Remembering
14.	Check whether the given discrete equation is stable or not by Jury's test. $\mathbf{i.F(Z)=Z^2-1.21Z+0.368=0}$ $\mathbf{ii.F(Z)=Z^3-0.5Z^2+2.49Z-0.496=0}$ (13) $\mathbf{iii.F(Z)=Z^4+1.5Z^3+3Z^2+1.25Z+0.25=0}$	BTL 4	Analyzing
15.	Find the pulse transfer function and stability analysis By (i) Jury's test ii) Bilinear transform for the sampled data control system is as shown in Fig. with sampling time i)T=0.1 Second ii) T=2 Seconds. (13)	BTL 4	Analyzing

			
16.	Check whether the given discrete characteristic equation of the system is stable or not by Bilinear transform (13) **i.** $F(Z) = Z^2 - 1.2Z - 0.363 = 0$ **ii.** $F(Z) = Z^2 - 0.4Z + 0.8 = 0$ **iii.** $F(Z) = Z^3 - 0.5Z^2 + 0.25Z + 0.5 = 0$	BTL 4	Analyzing
17.	Find the inverse Z-transform for the following transfer functions: (i). $F(Z) = \frac{(Z+1)}{(Z+0.2)(Z-1)}$ (ii). $F(Z) = \frac{Z^2 + Z^3}{(Z-1)(Z-3)}$ (ii). $F(Z) = \frac{Z^2}{Z^2 + Z + 2}$ (13)	BTL 4	Analyzing
PART C			
1.	Find the inverse Z-transform for the following functions using Partial Fraction Expansion method: (i). $F(Z) = \frac{Z(Z^2 - 4Z + 5)}{(Z-1)(Z-2)(Z-3)}$ (ii). $F(Z) = \frac{Z^2}{Z^2 + Z + 2}$ (iii). $F(Z) = \frac{Z^2}{Z^2 - Z + 0.5}$ (5+5+5)	BTL 4	Analyzing
2.	(i) Draw the block diagram of sampled data control systems with suitable. (7) (ii) Explain the properties of Z-Transform. (8)	BTL 4	Analyzing
3	Check for stability of the sampled data control system (i) Bilinear transform Method (ii) Jury's stability Test. (15)	BTL 4	Analyzing
4.	Check whether the given discrete equation is stable or not by Jury's test. **i.** $F(Z) = Z^2 - 1.21Z + 0.368 = 0$ **ii.** $F(Z) = Z^3 - 0.5Z^2 + 2.49Z - 0.496 = 0$ **iii.** $F(Z) = Z^3 + 0.5Z^2 + 0.25Z + 0.5 = 0$ (15)	BTL 4	Analyzing

5.	Check whether the given discrete characteristic equation of the system is stable or not by Bilinear transform (15) **i.** $F(Z) = Z^2 - 1.2Z - 0.363 = 0$ **ii.** $F(Z) = Z^2 - 0.4Z + 0.8 = 0$ **iii.** $F(Z) = Z^3 - 0.5Z^2 + 0.25Z + 0.5 = 0$	BTL 4	Analyzing

UNIT IV NONLINEAR SYSTEMSSTATE FEEDBACK CONTROL AND STATE ESTIMATOR

Introduction, common physical non linearites, The phase plane method: concepts, singular points, stability of non linear systems, construction of phase trajectories system analysis by phase plane method. The describing function method, stability analysis by describing function method, Jump resonance, Limit cycle.

PART A

Q.No.	Questions	BTL Level	Domain
1.	What is meant by Linear and Non-Linear System ? Give Example for each.	BTL 4	Analyzing
2.	What is meant by frequency entrainment ?	BTL 1	Remembering
3.	What is meant by asynchronous quenching ?	BTL 1	Remembering
4.	How the nonlinearity can be classified ? Give example for each.	BTL 1	Remembering
5.	Write describing function for nonlinear system.	BTL 1	Remembering
6.	What is hysteresis and backlash ?	BTL 6	Creating
7.	Mention any 2-methods used for the stability analysis of nonlinear system.	BTL 1	Remembering
8.	What is singular point ?	BTL 1	Remembering
9.	What is meant by autonomous system ?	BTL 1	Remembering

10.	Define the terms (i) Phase plane trajectory (ii) Phase portrait.	BTL 2	Understanding
11.	Write the describing function of ideal relay.	BTL 1	Remembering
12.	How the phase plane is distinguished with describing function method.	BTL 3	Applying
13.	Discuss the terms (i) Asymptotic stability (ii) Stable in Large.	BTL 2	Understanding
14.	What is meant by Jump resonance ?	BTL 4	Analyzing
15.	Illustrate the term autonomous system.	BTL 3	Applying
16.	What is meant by saturation ? Give example for each.	BTL 1	Remembering
17.	Express the term Phase Plane.	BTL 1	Remembering
18.	Mention any 2-properties of Non Linear system.	BTL 2	Understanding
19.	Write the Duffling's equation for nonlinear system,	BTL 6	Creating
20.	Define Describing function.	BTL 6	Creating
21.	What is meant by Limit cycles ?	BTL 4	Analyzing
22.	What is isocline of nonlinear system ?	BTL 3	Applying
23.	Express the term subharmonic oscillation.	BTL 1	Remembering
24.	Write the slope equation for phase plane trajectory ?	BTL 1	Remembering
PART – B			
1.	Express the difference between Linear system and Non-Linear System. Explain the different characteristics of the Nonlinear system. (13)	BTL 6	Creating
2.	Explain the phase plane trajectory formation by delta method. (13)	BTL 4	Analyzing

3.	Explain the following Non-Linear Properties (i) Frequency Amplitude Dependance (ii) Jump Resonance (iii) Sub Harmonic Oscillations (iv) Limit Cycle. (13)	BTL 4	Analyzing
4.	A servo system used for positioning a load has the backlash(K_N) G(S)=K/S(S+1)(S+2) in which X= Maximum value of input sinusoidal signal to nonlinearity using Polar Plot approach. (13)	BTL 4	Analyzing
5.	Draw the block diagram of describing function for the nonlinear system. Express with suitable diagram and mathematical expression with an example. (13)	BTL 2	Understanding
6.	Explain the following physical nonlinearity with suitable diagram (i) Saturation (ii) Dead Zone (iii) Friction (iv) Hysteresis. (13)	BTL 1	Remembering
7.	Explain the following Nonlinear concepts with example: (i) Jump Resonance (ii) Limit Cycle (iii) Frequency Entertainment. (13)	BTL 2	Understanding
8.	What is singular point ? Explain the Types of Singular point and draw the trajectory. (13)	BTL 3	Applying
9.	Describe the describing function analysis of the nonlinear systems with the general mathematical expression for each. (13)	BTL 4	Analyzing
10.	Explain the concept of Phase plane trajectory for nonlinear system with suitable example. (13)		Evaluating

11.	A linear second order servo system described by the equation e''+2Zwne'+w_n2 where Z=0.15, wn=1 rad/sec, e(0)=1.5,e'(0)=0 Determine the singular point. Construct the phase trajectory using isocline method. (13)	BTL 3	Applying
12.	Explain the nonlinearity function of relay using describing function method. (13)	BTL 6	Creating
13.	Explain the general design procedure for the phase plane trajectories for nonlinear systems. (13)	BTL 1	Remembering
14.	Construct a phase trajectory by delta method for a nonlinear system represented by the differential equation $\ddot{x}+4\lvert\dot{x}\rvert\dot{x}+4x=0$.Choose the initial conditions as x(0)=1.0 and x(0)=1.0, $\dot{x}$(0)=0. (13)	BTL 2	Understanding
15.	Explain the basic concept and mathematical expression for Describing function for Nonlinear system stability analysis. (13)	BTL 3	Applying
16.	Explain the following types of Nonlinertity Properties : (i) Jump Resonance (5) (ii) Limit Cycle (4) (iii) Frequency amplitude dependance (4)	BTL 4	Analyzing
17.	Explain the following Methods for the stability analysis of Nonlinear Systems : (i) Describing Function Method (7) (ii) Isocline Method (6)	BTL 4	Analyzing
PART C			
1.	Explain the following Non-Linear Properties (i) Frequency Amplitude Dependance (ii) Jump Resonance (iii) Sub Harmonic Oscillations(iv) Limit Cycle (v) Frequency Entertainment (vi) Asynchronous Quenching. (15)	BTL 4	Analyzing

2.	A servo system used for positioning a load has the backlash(K_N) G(S)=K/S(S+1)(0.5S+1) in which X= Maximum value of input sinusoidal signal to nonlinearity using Polar Plot approach. (15)	BTL 4	Analyzing
3.	Explain the following types of physical nonlinearity (i) Saturation (ii) Dead Zone (iii) Friction (iv) Hysteresis (v) Backlash. (15)	BTL 2	Understanding
4.	Construct a phase trajectory by delta method for a nonlinear system represented by the differential equation $\ddot{x}+4\lvert\dot{x}\rvert\dot{x}+4x=0$.Choose the initial conditions as x(0)=1.0 and x(0)=1.0, $\dot{x}$(0)=0. (15)	BTL 3	Applying
5.	Derive the expression using Describing function method for (i) Relay (ii) Saturation nonlinearity. (7+8)	BTL 6	Creating

UNIT V OPTIMAL CONTROL

Introduction: Classical control and optimization, formulation of optimal control problem, Typical optimal control performance measures - Optimal state regulator design: Lyapunov equation, Matrix Riccati equation - LQR steady state optimal control – Application examples.

PART A

Q.No.	Questions	BTL Level	Domain
1.	What is meant by Performance Index ?	BTL 1	Remembering
2.	Explain the following error criteria (i) ISE (ii) IAE (iii) ITAE (iv)ITSE.	BTL 2	Understanding
3.	Define positive definiteness of scalar functions. Give an example?	BTL 1	Remembering
4.	Point out Lyapunov's asymptotic stability.	BTL 5	Evaluating
5.	Formulate the expression for the quadratic performance	BTL 1	Remembering

	index.		
6.	Formulate the expression for the integral square error for performance index.	BTL 5	Evaluating
7.	Examine what is meant by autonomous system?	BTL 3	Applying
8.	Write the formulae sufficient condition for Hessian Matrix.	BTL 2	Understanding
9.	Illustrate the Lyapunov's instability theorem.	BTL 3	Applying
10.	Define positive semi definiteness of scalar functions. Give an example?	BTL 1	Remembering
11.	Draw and quote graphical representation of stable, asymptotic stable and unstable equilibrium states with their trajectory .	BTL 1	Remembering
12.	Show that the following quadratic form is + ve definite. $V(X)=10x_1^2 +4x_2^2 +x_3^2+2x_1x2-2x\ 2x3\ -4x1x_3$	BTL 3	Applying
13.	Determine whether the following quadratic form is – ve definite. $V(X) = -x_1^2 -3x_2^2 -11x_3^2 + 2x_1x_2 -4x_2x_3-2x_1x_3$	BTL 2	Understanding
14.	What is meant by optimization ?	BTL 4	Analyzing
15.	Express the term output regulator problem.	BTL 4	Analyzing
16.	Invent the necessary and sufficient condition for stability analysis?	BTL 6	Creating
17.	What reduced matrix Riccati equation ?	BTL 6	Creating
18.	List out various methods for stability analysis of non linear system.	BTL 1	Remembering
19.	What is meant by infinite time regulator problem ?	BTL 1	Remembering
20.	How the optimization concept can be done by Matrix Riccati equation ?	BTL 1	Remembering
21.	Express the term Optimal state regulator.		

22.	Write the Formulae for Matrix Riccati equation.		
23.	Why the LQR concept is preferred for optimization ?		
24.	Express the term LQR steady state optimal control concept.		

PART – B

1.	Explain the state regulator problem for Discrete Time Systems with an example. (13)	BTL 1	Remembering
2.	Explain the Lyapunov's stability criteria with diagrammatic representation (i) Asymptotically stable (ii) Stable (iii) Unstable. (13)	BTL 4	Analyzing
3.	Examine Lyapunov's stability analysis for (i) Linear time invariant system (ii) Nonlinear Continuous system. (13)	BTL 3	Applying
4.	Explain the Lyapunov's criterion stability analysis for (i) Continuous system (ii) Discrete time systems. (13)	BTL 5	Evaluating
5.	Explain the following optimal control concept with an example: (i) Matrix Riccati equation (7) (ii) LQR steady state optimal Control Method (6)	BTL 2	Understanding
6.	Summarize direct method of Lyapunov's function how it can be applicable for the nonlinear continuous time system. (13)	BTL 2	Understanding
7.	Examine Lyapunov's direct method of Lyapunov for Continuous time autonomous system. (13)	BTL 1	Remembering
8.	Explain with an example for optimal control concept of : (i) Matrix Riccati equation (7) (ii) LQR steady state optimal control (6)	BTL 1	Remembering
9.	Design and determine if the following matrix is positive definite.	BTL 6	Creating

	$V(X)=10x_1^2 + 4x_2^2 + x_3^2 + 2x_1x_2 - 2x_2x_3 - 4x_1x_3$ (13)		
10.	Estimate direct method of Lyapunov's function how it can be applicable for nonlinear continuous time system. (13)	BTL 2	Understanding
11.	Illustrate the following methods for stability analysis (i)Krasovskii Method (ii) Variable-Gradiant Method with suitable example. (13)	BTL 3	Applying
12.	Describe Lyapunov's Method Stability analysis with suitable example : (i) Linear System (7) (ii) Non-Linear System. (6)	BTL 1	Remembering
13.	Derive the expression for the optimal control problem by transfer function approach. (13)	BTL 4	Analyzing
14.	Derive the expression for the optimal control problem by state variable approach. (13)	BTL 4	Analyzing
15.	Obtain the expression for the Matrix Riccati Equation.(13)	BTL 3	Applying
16.	Explain with an example for LQR steady state optimal control. (13)	BTL 1	Remembering
17.	Express the concept of optimal state regulator by Matrix Riccati Equation. (13)	BTL 4	Analyzing
	PART C		
1.	Illustrate the following stability concepts (I) Lyapunov's Method stability at origin (ii) Lyapunov's Method stability in stable boundary (iii) Lyapunov's Method for unstable condition. (15)	BTL 3	Applying
2.	Explain the state regulator problem for (i) Discrete Time Systems (ii) Continuous Time Systems. (15)	BTL 2	Understanding
3.	Evaluate the expression for LQR steady state optimal control. (15)	BTL 5	Evaluating
4.	Derive the expression for the Matrix Riccati Equation and explain with suitable case study for it. (15)	BTL 4	Analyzing
5.	Evaluate the expression for the parameter optimization for Servo Mechanism or Tracking Problem. (15)	BTL 5	Evaluating