SRM VALLIAMMAI ENGINEERING COLLEGE
(An Autonomous Institution)
SRM Nagar, Kattankulathur – 603 203

DEPARTMENT OF

ELECTRICAL AND ELECTRONICS ENGINEERING

QUESTION BANK

ME-Control and Instrumentation Engineering

1913102-SYSTEM THEORY

Regulation – 2019

Academic Year 2019–20

Prepared by

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1913104 SYSTEM THEORY **L T P C** **3 2 0 4**

UNIT I STATE VARIABLE REPRESENTATION 9

Introduction-Concept of State-State equations for Dynamic Systems -Time invariance and linearity- Non uniqueness of state model- Physical Systems and State Assignment - free and forced responses- State Diagrams.

UNIT II SOLUTION OF STATE EQUATIONS 9

Existence and uniqueness of solutions to Continuous-time state equations - Solution of Nonlinear and Linear Time Varying State equations - State transition matrix and its properties – Evaluation of matrix exponential- System modes- Role of Eigen values and Eigen vectors.

UNIT III STABILITY ANALYSIS OF LINEAR SYSTEMS 9

Controllability and Observability definitions and Kalman rank conditions -Stabilizability and Detectability-Test for Continuous time Systems- Time varying and Time invariant case-Output Controllability-Reducibility- System Realizations.

UNIT IV STATE FEEDBACK CONTROL AND STATE ESTIMATOR 9

Introduction-Controllable and Observable Companion Forms-SISO and MIMO Systems- The Effect of State Feedback on Controllability and Observability-Pole Placement by State Feedback for both SISO and MIMO Systems-Full Order and Reduced Order Observers.

UNIT V LYAPUNOV STABILTY ANALYSIS 9

Introduction-Equilibrium Points- BIBO Stability-Stability of LTI Systems- Stability in the sense of Lyapunov - Equilibrium Stability of Nonlinear Continuous-Time Autonomous Systems-The Direct Method of Lyapunov and the Linear Continuous-Time Autonomous Systems-Finding Lyapunov Functions for Nonlinear Continuous-Time Autonomous Systems– Krasovskil's and Variable-Gradiant Method. **TOTAL : 45+30 = 75 PERIODS**

TEXT BOOKS:

1. M. Gopal, "Modern Control System Theory", New Age International, 2005.
2. K. Ogatta, "Modern Control Engineering", PHI, 2002.
3. John S. Bay, "Fundamentals of Linear State Space Systems", McGraw-Hill, 1999.
4. D. Roy Choudhury, "Modern Control Systems", New Age International, 2005.
5. John J. D'Azzo, C. H. Houpis and S. N. Sheldon, "Linear Control System Analysis and Design with MATLAB", Taylor Francis, 2003.
6. Z. Bubnicki, "Modern Control Theory", Springer, 2005.
7. C.T. Chen, "Linear Systems Theory and Design'' Oxford University Press, 3rd Edition, 1999.
8. M. Vidyasagar,"Nonlinear Systems Analysis', 2nd edition, Prentice Hall, Englewood Cliffs, New Jersey.

UNIT I STATE VARIABLE REPRESENTATION

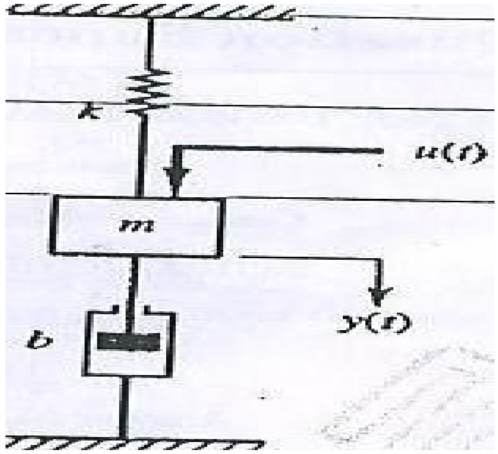
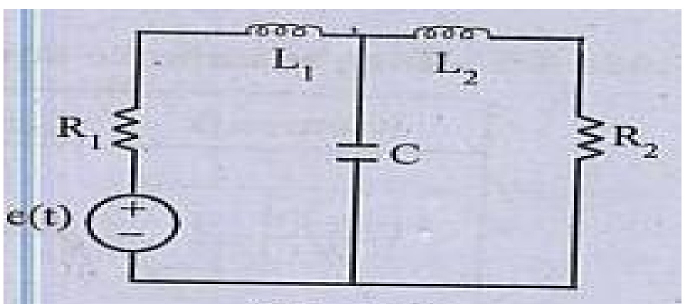
Introduction-Concept of State-State equations for Dynamic Systems -Time invariance and linearity- Non uniqueness of state model- Physical Systems and State Assignment - free and forced responses- State Diagrams.

PART A

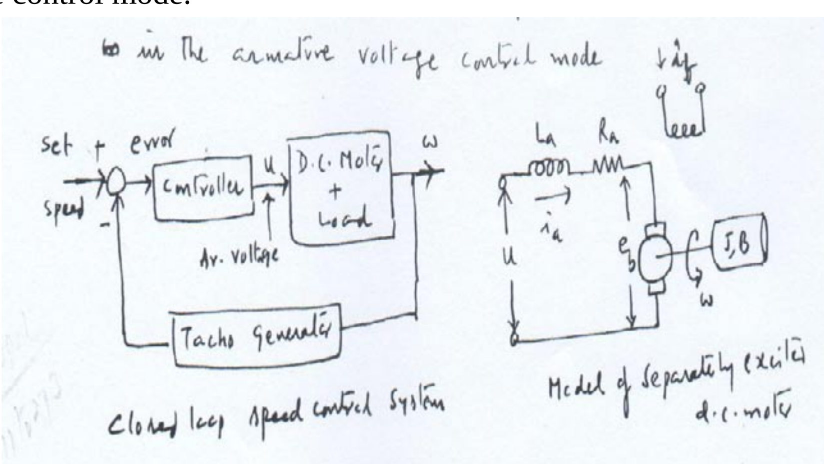
Q.No.	Questions	BTL Level	Domain
1.	Examine the general form of the state space model for continuous system. And also write the state diagram.	BTL 1	Remembering
2.	Define the following terms such as (i) State (ii) State Variable (iii) State Vector (iv) State Space Model.	BTL 1	Remembering
3.	Give any two approach to convert the transfer function approach to the state space model.	BTL 1	Remembering
4.	List the drawbacks in transfer function model analysis?	BTL 1	Remembering
5.	Define the terms (i) Linearity (ii) Time invariance.	BTL 1	Remembering
6.	Define the term (i) Non-uniqness of the state space model.	BTL 1	Remembering
7.	Express the state space model for a simple (i) Mass–Spring–Damper System (ii) Mechanical Rotational System.	BTL 2	Understanding
8.	Express the Formula in which the general form of state space model into transfer functional approach.	BTL 2	Understanding
9.	How the Diagonal canonical form is distinguished with Jordon Canonical form.	BTL 2	Understanding
10.	Distinguish the difference between (i) Physical variable model (ii) Phase Variable model.	BTL 2	Understanding

11.	Obtain the state space model for the given differential equation $\frac{d^3Y}{dt^2}+6\frac{d^2Y}{dt^2}+11\frac{dY}{dt}+6Y=U(t)$ Solve and obtain the transfer function model.	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.	Compare the merits and demerits of realizing a given system in state variable and transfer function form.	BTL 4	Analyzing
15.	Derive and explain the transfer function model of a LTI system whose state equation is given by $X=\begin{bmatrix}1 & 2\\ 1 & 1\end{bmatrix}X+\begin{bmatrix}1\\ -1\end{bmatrix}U$ $Y=\begin{bmatrix}1 & 1\end{bmatrix}X$	BTL 4	Analyzing
16.	Explain the applications of state space model for the different system.	BTL 4	Analyzing
17.	Summarize the draw backs of transfer function model compare with state space model.	BTL 5	Evaluating
18.	Judge any 2-methods for the conversion of transfer functional model into state space model.	BTL 5	Evaluating
19.	Formulate state space model with state diagram for observable canonical form.	BTL 6	Creating
20.	Develop state space model with state diagram for controllable canonical form.	BTL 6	Creating

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. (16)	BTL 5	
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. (16)	BTL 6	Creating
3.	Analyze the state model of the following electrical system. (16)  *Fig 4.1.1.*	BTL 4	Analyzing
4.	Calculate the state space model for (i) Series RLC Circuit. (16)	BTL 3	Applying
5.	Illustrate the expression for the state space model for the continuous system and also draw the state diagram for it. (16)	BTL3	Applying
6.	Formulate the expression for the (i) Controllable canonical form (ii) Observable Canonical form. (16)	BTL 6	Creating
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. (16)	BTL 3	Applying
8.	Evaluate the state space model for the given differential equation	BTL 5	Evaluating

	$\frac{d^3Y}{dt^2}+6\frac{d^2Y}{dt^2}+11\frac{dY}{dt}+6Y=U(t)$ by Canonical form or companion form method and also draw the state diagram for it. (16)		
9.	A discrete time system is represented by the differential equation $y(n+2)+6y(n+1)+8y(n)=u(n)$ in which the initial condition y(0)=y(1)=0 with T=1Second (i)Estimate the controllable Canonical discrete state space model. (16)	BTL 2	Understanding
10.	Define the terms (i) Linearity (ii) Non uniqueness (iii) Time invariance for state space model. (16)	BTL 1	Remembering
11.	Illustrate the expression for the state space model for continuous system. (16)	BTL 3	Applying
12.	Evaluate the method for converting the transfer function into state space model (i) Bush Form (or) Companion form (ii)Signal Flow Graph Method (iii) Canonical Form Method. (16)	BTL 5	Evaluating
13.	Solve the state space model for the given system(i) Y(S)/U(S)=8/(S+1)(S+2)(S+3) by the method of (i) Laplace Transform (ii) Signal Flow Graph Method. (16)	BTL 3	Applying
14.	Create the state space model by using signal flow graph for the given problem (i) $Y(S)/U(S)=10/(S^3+5S^2+4S+10)$ (16)	BTL 6	Creating
	PART C		
1	Derive the state model for a separately excited d.c. motor used in the armature voltage control mode.	BTL 5	Evaluating



2	Discuss in detail about the requirement of Conversion of state variable model into transfer function model.	BTL 6	Creating
3	Evaluate the free and forced responses and state transition matrix with suitable example.	BTL 6	Evaluating
4	Discuss about the uniqueness of state model and state assignment with suitable model.	BTL 5	Creating

UNIT II SOLUTION OF STATE EQUATIONS

Existence and uniqueness of solutions to Continuous-time state equations - Solution of Nonlinear and Linear Time Varying State equations - State transition matrix and its properties – Evaluation of matrix exponential- System modes- Role of Eigen values and Eigen vectors.

PART A

Q.No.	**Questions**	**BTL Level**	**Domain**
1.	What is the state transition matrix ? List any two methods for finding state transition matrix.	BTL 1	Remembering
2.	Quote the formula for the solution of the state equation in time domain?	BTL 1	Remembering
3.	What is eigen values and eigen vectors ? Examine how the eigen values can be calculated?	BTL 1	Remembering
4.	What is state transition matrix and identify how it is related to state of a system?	BTL 1	Remembering
5.	Describe the formula for Matrix exponential method.	BTL 1	Remembering
6.	Quote the different methods available for computing e^{At}?	BTL 1	Remembering
7.	Summarize the term Jordan canonical form.	BTL 2	Understanding
8.	Predict the transformation used to diagonalize a system matrix?	BTL 2	Understanding
9.	Estimate the transformed canonical state model of a system?	BTL 2	Understanding

10.	Express the term Model Matrix and explain with suitable formulae..	BTL 2	Understanding
11.	Demonstrate how the modal matrix can be determined?	BTL 3	Applying
12.	Illustrate Cayley-Hamilton theorem.	BTL 3	Applying
13.	Examine How the state transition matrix e^{At} is computed by canonical transformation.	BTL 3	Applying
14.	Analyze how the state transition matrix e^{At} is computed using Cayley-Hamilton theorem?	BTL 4	Analyzing
15.	Point out how the state transition matrix and how it is related to state of a system?	BTL 4	Analyzing
16.	Explain the solution of homogeneous state equations.	BTL 4	Analyzing
17.	Write the solution of non-homogeneous state equations.	BTL 5	Evaluating
18.	Judge the term resolvant matrix.	BTL 5	Evaluating
19.	Formulate the state transition matrix by Laplace Transform method $A = \begin{bmatrix} 0 & 5 \\ -1 & -2 \end{bmatrix}$	BTL 6	Creating
20.	Formulate the state transition matrix by Matrix Exponential method $A = \begin{bmatrix} -1 & 1 \\ 0 & -1 \end{bmatrix}$	BTL 6	Creating
	PART – B		
1.	Illustrate the expression by (i) Matrix Exponential Method (ii) Laplace Transform Method for state transistion of matrix. (16)	BTL 3	Applying
2.	Obtain the 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] $\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$ Convert the state space model into canonical form state space model. And also calculate the value of state transition matrix. (16)	BTL 3	Applying

3.	State Cayley-Hamilton's Theorem. Derive and explain the expression state transition matrix using Cayley- Hamilton's theorem for continuous system. (16)	BTL 4	Analyzing
4.	Evaluate the state transition matrix for the given discrete system matrix $A=\begin{bmatrix}0 & 1\\ -12 & 7\end{bmatrix}$.By i. Z-transform technique ii.Cayley-Hamilton's theorem. (16)	BTL 5	Evaluating
5.	The given state space model $A=\begin{bmatrix}0 & 0 & 1\\ -2 & -3 & 0\\ 0 & 2 & -3\end{bmatrix}$; Calculate the (i) Eigen values and Eigen vectors (ii) Rank of the matrix. (16)	BTL 3	Applying
6.	Evaluate the value of e^{At} by (i) Trial and Error Method (ii) Cayley Hamilton's Theorem. $A=\begin{bmatrix}0 & 1\\ -2 & -3\end{bmatrix}$ (16)	BTL 5	Evaluating
7.	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 $A=\begin{bmatrix}0 & 1\\ -12 & 7\end{bmatrix}$ (16)	BTL 4	Analyzing
8.	The given matrix $A=\begin{bmatrix}-1 & 1 & 1\\ 0 & -1 & 1\\ 0 & 0 & --1\end{bmatrix}$; Calculate the state transistion matrix by using Laplace transform method. (16)	BTL 3	Applying
9.	The given matrix $A=\begin{bmatrix}2 & 1 & 4\\ 0 & 2 & 0\\ 0 & 3 & 1\end{bmatrix}$; Estimate the value of state transistion matrix by using Cayley Hamilton's Theorem. (16)	BTL 2	Understanding
10.	Convert the transfer function for the state space model and calculate $\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix}=\begin{bmatrix}0 & 1\\ -3 & -2\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}+\begin{bmatrix}0\\ 2\end{bmatrix}U$; y=[1 0] $\begin{bmatrix}x_1\\ x_2\end{bmatrix}$	BTL 3	Applying

	$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -5 & -1 \\ 3 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 2 \\ 5 \end{bmatrix} U \text{ ; y=[1 2]} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$ $$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -0.4 & -1.3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} U \text{ ; y=[0.8 1]} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$ (16)		
11.	Solve and Calculate 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 $A = \begin{bmatrix} 0 & 1 \\ -12 & 7 \end{bmatrix}$ (16)	BTL 3	Applying
12.	Find and point out the value of e^{At} by (i) Trial and Error Method (ii) Cayley Hamilton's Theorem. $A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$ (16)	BTL 4	Analyzing
13.	Consider a system whose transfer function is given by Y(S)/U(S) = $10(S+1)/S^3+6S^2+5S+10$ Evaluate the state model for the system (i) by Block diagram reduction (ii) Signal flow graph Method. (16)	BTL 5	Evaluating
14.	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. (16)	BTL 6	Creating
	PART C		
1	Discuss the role of eigen values and eigen vectors in analyzing the system behavior.What is the effect of state feedback in system behavior.	BTL 6	Creating
2.	Discuss the basic elements used to construct the state diagram. Analyse the requirement for each and every blocks.	BTL 6	Creating

3	Analyse the solutions involved in the non linear and linear time invarying systems with suitable examples.	BTL 5	Evaluating
4.	When a linear state model is said to be reducible? Explain with suitable system.	BTL 5	Evaluating

UNIT III STABILITY ANALYSIS OF LINEAR SYSTEMS

Controllability and Observability definitions and Kalman rank conditions-Stabilizability and Detectability-Test for Continuous time Systems-Time varying and Time invariant case- Output Controllability-Reducibility- System Realizations.

PART A

Q.No.	Questions	BTL Level	Domain
1.	Quote what is meant by the rank of the matrix ?	BTL 1	Remembering
2.	Define the duality of the system between controllability and observability concept?	BTL 1	Remembering
3.	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] $\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$ Tell whether the given is controllable	BTL 1	Remembering
4.	Examine the need for observability test?	BTL 1	Remembering
5.	Describe the condition for observability by Gilbert’s method.	BTL 1	Remembering
6.	When the Controllability test is normally applicable ?.	BTL 1	Remembering
7.	Summarize the condition for controllability by Gilbert’s method.	BTL 2	Understanding
8.	Describe the condition for controllability by Kalman’s method.	BTL 2	Understanding
9.	What is meant by minimal realization? Give the expression for it.	BTL 2	Understanding

10.	Discuss the effect of pole zero cancellation in transfer function approach.	BTL 2	Understanding
11.	Illustrate the concept of stabilizability.	BTL 3	Applying
12.	Illustrate the concept of detectability.	BTL 3	Applying
13.	Discover the advantage and disadvantage in Kalman's test for observability?	BTL 3	Analyzing
14.	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] $\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$ Solve whether the given is controllable	BTL 3	Applying
15.	Analyze the condition for O/P controllability by Kalman;s method.	BTL 4	Analyzing
16.	Analyze the condition for observability by Kalman's method.	BTL 4	Analyzing
17.	Given two equivalent mathematical expressions which state that a given pair of matrices(A, B) is controllable. Evaluate the expression.	BTL 5	Evaluating
18.	Write the Ackerman's formula for state feed back gain and explain it.	BTL 5	Evaluating
19.	Create the formula for Observability of the system.	BTL 6	Creating
20.	What is meant by duality of the system. Develop the expression by Kalman's Method.	BTL 6	Creating

PART – B

1.	What is meant by rank of the matrix ? Tell Whether the rank of the matrix depends on controllability or not explain it. (16)	BTL 1	Remembering
2.	Define the concept of Controllability and observability of the system.Write the expression for the controllability and observability in (i) Kalman's Method (ii) Gillbert's Method. (16)	BTL 1	Remembering

3.	Derive and Examine the expression for the (i) Controllable canonical form (ii) Observable Canonical Form. (16)	BTL 1	Remembering
4.	The given state space model $\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix}=\begin{bmatrix}0&0&1\\-2&-3&0\\0&2&-3\end{bmatrix}\begin{bmatrix}x_1\\x_2\\x_3\end{bmatrix}+\begin{bmatrix}0\\2\\0\end{bmatrix}U$; y=[1 0 0]$\begin{bmatrix}x_1\\x_2\\x_3\end{bmatrix}$ Check and Tell whether the given is controllable and observable or not by Kalman's approach and Gilbert's method. (16)	BTL 1	Remembering
5.	The given state space model $\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix}=\begin{bmatrix}0&1&1\\0&0&1\\-1&-5&-6\end{bmatrix}\begin{bmatrix}x_1\\x_2\\x_3\end{bmatrix}+\begin{bmatrix}0\\0\\10\end{bmatrix}U$; 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 also check the duality by Kalman's approach and Gilbert's method. (16)	BTL 2	Understanding
6.	The transfer function of the system Y(S)/U(S)=3/S^3+6S^2+11S+6. Check and express whether the given system is controllable as well as observable. And also check the duality. by Kalman's approach and Gilbert's method. (16)	BTL 2	Understanding
7.	Estimate the controllable canonical realization of the following systems. Hence, obtain the state space model in controllable canonical form (i) H(S)=(S+2)/(S+5) (ii) H(S)=(S+2)/(S^2+2S+5) (iii) H(S)=(2S+9)/(S^3+8S^2+12S+1) (iv) H(S)=(S^2+2S+3)/(S^4+3S^3+12S^2+9S+10) (16)	BTL 2	Understanding
8.	Illustrate the expression for the Controllability and Observability in (i) Kalman's Method (ii)Gilbert's Method. (16)	BTL 3	Applying

9.	Explain and demonstrate the (i) Reducibility (ii) System Realization. Explain with an example for each for solving a problem. (16)	BTL 3	Applying
10.	Explain with an example explain (i) Output Controllability and Observability (ii) Controllable and Observability concept applicable for time varying and invariant system. (16)	BTL 4	Analyzing
11.	Consider a system with state space model is given below. $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 2 \\ 0 & 0 & 1 \\ -1 & -2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 4 \end{bmatrix} U$; y=[2 -4 0] $\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$ Point out that the system is observable and controllable. (16)	BTL 4	Analyzing
12.	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. (16)	BTL 4	Analyzing
13.	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. (16)	BTL 5	Evaluating
14.	(i) Consider a system whose transfer function is given by Y(S)/U(S) = 10(S+1)/S^3+6s^2+5s+10 . Solve and explain state model for this system. (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. And also check the duality principle. (16)	BTL 4	Analyzing

	PART C		
1	What is the effect of state feedback on controllability and observability of a system? Discuss with suitable examples	BTL 6	Creating
2	Consider a state-space system in which A= 0 1 B = 0 0 3 1 Is this completely controllable	BTL 5	Evaluating
3	Analyse the conditions for kalman test and Gilberts test with suitable examples. Also justify the selection of these test for particular systems	BTL 5	Evaluating
4	Discuss the pros and cons of the tests available in testing the controllability and observability of a system.	BTL 6	Creating

UNIT IV STATE FEEDBACK CONTROL AND STATE ESTIMATOR

Introduction-Controllable and Observable Companion Forms-SISO and MIMO Systems- The Effect of State Feedback on Controllability and Observability-Pole Placement by State Feedback for both SISO and MIMO Systems-Full Order and Reduced Order Observers.

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 4	Analyzing
2.	Analyze the need for state observer for the system?	BTL 4	Analyzing
3.	Summarize the following terms (i) Full-order observer (ii) Reduced-order observer (iii) Minimum-order state observer?	BTL 2	Understanding
4.	What is the necessary condition to be satisfied for the design of state observer? Also Write the Ackermann's formula to identify the state observer gain matrix, G.	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	BTL 6	Creating

	gain matrix, K.		
7.	Illustrate the general form of observable phase variable form of state model.	BTL 3	Applying
8.	Summarize the pole placement controller by state feedback?	BTL 5	Evaluating
9.	How will you Evaluate the transformation matrix, P_O to the state model to observable phase variable form?	BTL 5	Evaluating
10.	How control system design is carried in state space and discuss with an suitable example.	BTL 2	Understanding
11.	Quote the necessary condition to be satisfied for design using state feedback?	BTL 1	Remembering
12.	Illustrate the block diagram of a system with state feedback concept for controller.	BTL 3	Applying
13.	Express the general form of controllable phase variable form of state model approach.	BTL 2	Understanding
14.	What is meant by Control law? And also write the gain formulae and analyze the Ackermann's Method.	BTL 4	Analyzing
15.	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
16.	How will you examine the transformation matrix, Pc to transform the state model to controllable phase variable form using the characteristic equation?	BTL 1	Remembering
17.	A system exhibits critically damped response for a step input and has a natural frequency of oscillation of 10rad/sec. Quote the equivalent pole locations.	BTL 1	Remembering
18.	Discuss obsevability of the system and explain with an diagram.	BTL 2	Understanding
19.	Formulate the state space model with state diagram for controllable canonical form	BTL 6	Creating

20.	Formulate the state space model with state diagram for observable canonical form.	BTL 6	Creating
PART – B			
1.	Examine the design of pole placement concept for SISO and MIMO System with suitable diagram and expression. (16)	BTL 1	Remembering
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 $\mu_1 = -5; \mu_2 = -5$. (16)	BTL 1	Remembering
3.	Explain the controllable canonical form and observable canonical form for an example. (16)	BTL 4	Analyzing
4.	Obtain and analyze the expression for (i) Full order observer (ii) Reduced Order Observer (iii) Pole Placement of Controller. (16)	BTL 4	Analyzing
5.	Describe the effect of feedback on the concept of Controllability and Observability of the system. (16)	BTL 2	Understanding
6.	Describe in detail the concept of state space model for full order observer and reduced order observer. (16)	BTL 1	Remembering
7.	Discuss briefly about the controllable and observable forms of SISO systems. (16)	BTL 2	Understanding
8.	(i) Illustrate the Controllable Canonical Form and Observable Canonical forms for MIMO system. (ii) Illustrate the effect of state feedback on Controllability and Observability. (16)	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, (16)	BTL 4	Analyzing

10.	The given state space model as follows $$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 \\ -2 & -3 & 0 \\ 0 & 2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 2 \\ 0 \end{bmatrix} U \text{; } y=[1\ 0\ 0] \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$ Convert the state model into observable phase variable format and evaluate it. (16)	BTL 5	Evaluating
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. (16)	BTL 3	Applying
12.	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 express a full-order state observer. The desired Eigen values for the observer matrix $\mu_1 = -5; \mu_2 = -5$. (16)	BTL 6	Creating
13.	What is meant by observer ? How the observer coincept related with Observability. Examine the following types of observer (i) Full Order Observer (ii) Reduced Order Observer. (16)	BTL 1	Remembering
14.	Estimate the following types of Canonical form with expression for (i) Controllable Canonical Form (ii) Observable Canonical Form. (16)	BTL 2	Understanding
	PART B		
1	Analyse the conversion techniques of different canonical forms by considering a single system.	BTL 5	Evaluating
2	Explain the step by step procedure for finding a linear state variable feedback controller for a LTI system by pole placement technique.	BTL 6	Creating
3	Analyze the state diagram and explain with an example for state space with feed back (i) Full Order (ii) Reduced Order Observer.	BTL 5	Evaluating
4	Analyze the (i) Full order observer (ii) Reduced Order Observer (iii) Pole Placement of Controller for an LTI system. Consider own example.	BTL 5	Evaluating

UNIT V LYAPUNOV STABILTY ANALYSIS

Introduction-Equilibrium Points- BIBO Stability-Stability of LTI Systems- Stability in the sense of Lyapunov - Equilibrium Stability of Nonlinear Continuous-Time Autonomous Systems-The Direct Method of Lyapunov and the Linear Continuous-Time Autonomous Systems-Finding Lyapunov Functions for Nonlinear Continuous-Time Autonomous Systems – Krasovskil's and Variable-Gradiant Method.

PART A

Q.No.	Questions	BTL Level	Domain
1.	Define (i) Conditionally Stable (ii) Limitedly Stable (iii) Marginally Stable (iv) Unstable.	BTL 1	Remembering
2.	Explain BIBO stability.	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.	Define the term stability.	BTL 1	Remembering
6.	Evaluate the concept of equilibrium points?	BTL 5	Evaluating
7.	Examine what is meant by autonomous system?	BTL 3	Applying
8.	Summarize the negative definiteness of scalar functions. Give an example?	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. $V(X)=10x_1^2 +4x_2^2 +x_3^2+2x_1x_2-2x_2x_3 -4x_1x_3$	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.	In routh array Analyze the conclusions you can make when there is arrow of all zeros?	BTL 4	Analyzing

15.	Analyze the concept of limitedly stable system?	BTL 4	Analyzing
16.	Invent the necessary and sufficient condition for stability?	BTL 6	Creating
17.	A system has repeated Eigen values on imaginary axis. What can you create about the asymptotic stability of the system?.	BTL 6	Creating
18.	List out various methods for stability analysis of non linear system.	BTL 1	Remembering
19.	Define Lyapunov's sufficient condition for asymptotic stability.	BTL 1	Remembering
20.	Mention the advantages of Lyapunov's stability criteria.	BTL 1	Remembering
	PART – B		
1.	Describe the modeling energy system in terms of quadratic function.	BTL 1	Remembering
2.	Explain the Lyapunov's stability criteria with diagrammatic representation (i) Asymptotically stable (ii) Stable (iii) Unstable.	BTL 4	Analyzing
3.	Examine the Lyapunov's stability analysis for (i) Linear time invariant system (ii) Nonlinear Continuous system.	BTL 3	Applying
4.	Explain the Lyapunov's criterion stability analysis for (i) Continuous system (ii) Discrete time systems.	BTL 5	Evaluating
5.	Summarize Krasovskii method and how it can be applicable for stability analysis explain with an example for it.	BTL 2	Understanding
6.	Summarize direct method of Lyapunov's function how it can be applicable for nonlinear continuous time system.	BTL 2	Understanding
7.	Examine Lyapunov's direct method of Lyapunov for Continuous time autonomous system.	BTL 1	Remembering
8.	Examine the following terminology (i) Stability in the sense of Lyapunov (ii) BIBO Stability for Linear Time Invarient System.	BTL 1	Remembering
9.	Design and determine if the following matrix is positive definite. $V(X)=10x_1^2+4x_2^2+x_3^2+2x_1x_2-2x_2x_3-4x_1x_3$	BTL 6	Creating
10.	Estimate the direct method of Lyapunov's function how it can be applicable for nonlinear continuous time system.	BTL 2	Understanding

11.	Illustrate the following methods for stability analysis (i)Krasovskii Method (ii) Variable-Gradiant Method with suitable example.	BTL 3	Applying
12.	Describe Lyapunov’s Method Stability analysis for (i) Linear System (ii) Non-Linear System with suitable example.	BTL 1	Remembering
13.	What is meant by autonomous of the system ? Analyze how the Lyapunov’s Method applicable for Linear and Nonlinear autonomous system.	BTL 4	Analyzing
14.	Explain following stability concepts (I) Lyapunov’s Method stability at orgin (ii) Lyapunov’s Method stability in stable boundary (iii) Lyapunov’s Method for unstable condition.	BTL 4	Analyzing
	PART C		
1	Obtain an elaborate report on various techniques available in stability analysis concepts for linear and non linear systems.	BTL 6	Creating
2	Show that state feedback controller and estimator can be designed independent of each other with suitable systems.	BTL 6	Creating
3	Consider a non linear system were the nonlinear element is described by $u = g(e) = e^2$ Find the region of asymptotic stability around the equilibrium point at orgin.	BTL 5	Evaluating
4	Determine the system stability of the given system and evaluate its stability at origin using lyapunovs direct method. $\dot{x} = \begin{matrix} -1 & -2 \\ 1 & -4 \end{matrix}$	BTL 5	Evaluating