DHANALAKSHMI SRINIVASAN COLLEGE OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF

ELECTRICAL AND ELECTRONICS ENGINEERING

QUESTION BANK

V SEMESTER

IC6501 – CONTROL SYSTEMS

Regulation– 2013

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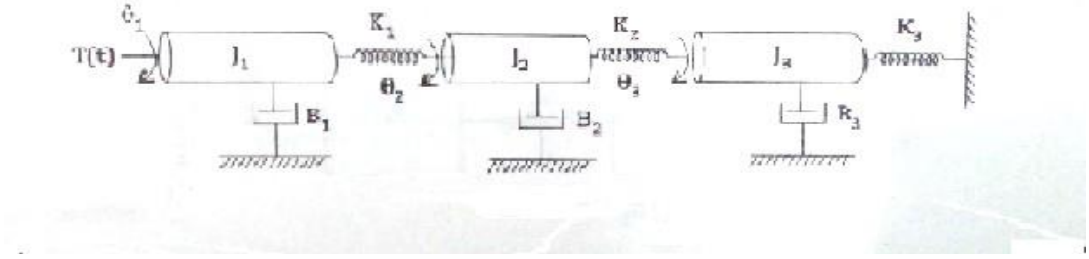
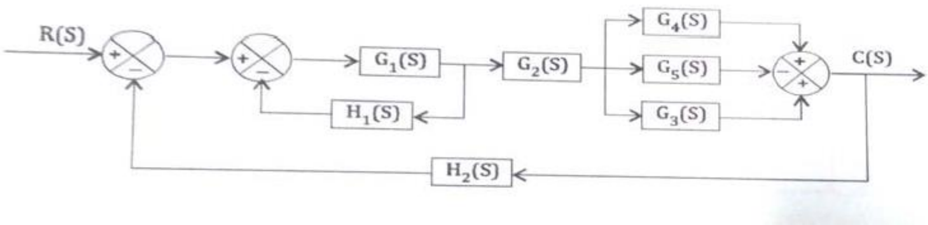
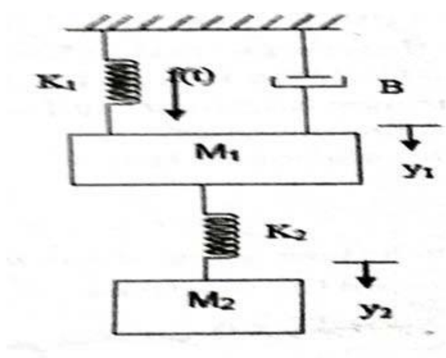
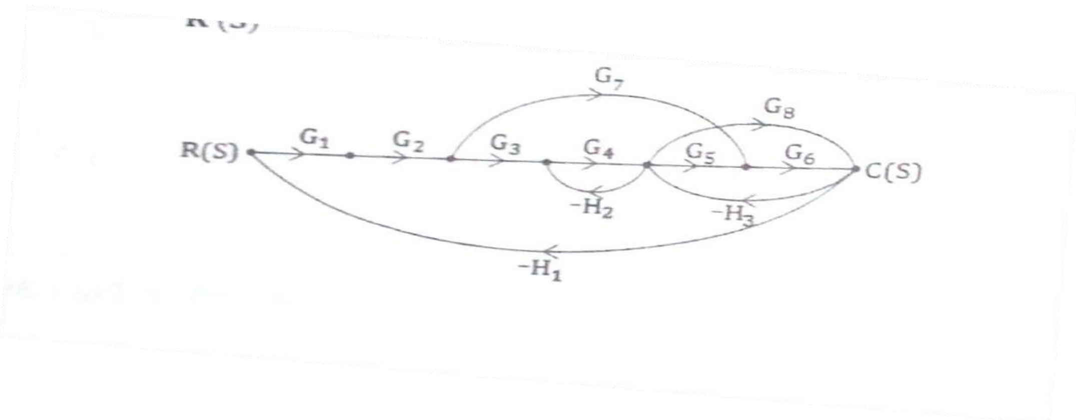
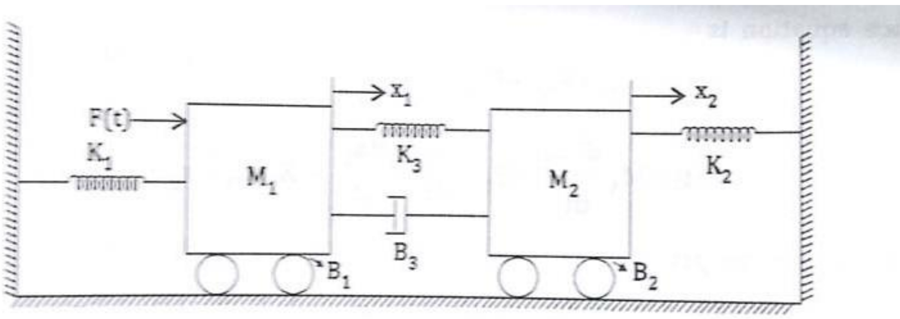
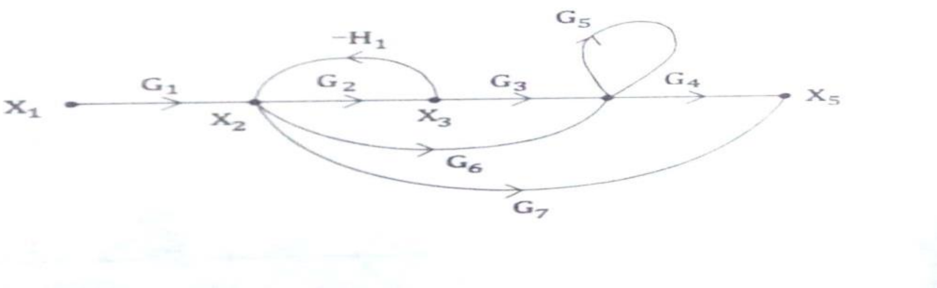
UNIT I SYSTEMS AND THEIR REPRESENTATION

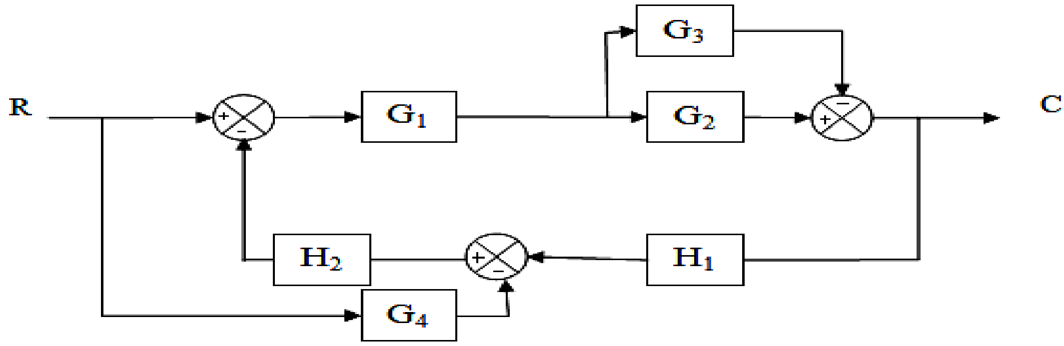
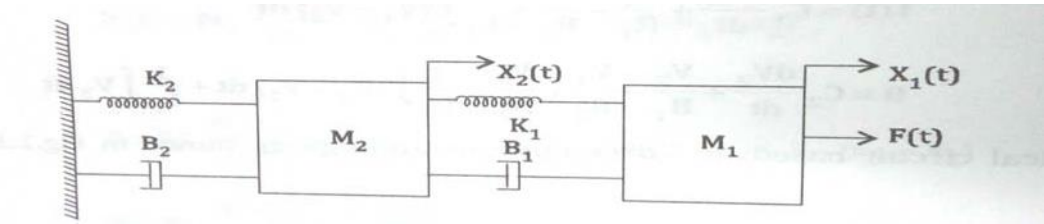
Basic elements in control systems – Open and closed loop systems – Electrical analogy of mechanical and thermal systems – Transfer function – Synchros – AC and DC Servomotors – Block diagram reduction techniques – Signal flow graphs.

PART A

Q.No.	Questions	BTL Level	Domain
1.	List the advantages of closed loop system over open loop system.	BTL 1	Remembering
2.	Define the terms (i) Physical Model (ii) Mathematical Model.	BTL 1	Remembering
3.	What are the basic elements in control systems?	BTL 1	Remembering
4.	Define transfer function. Give an example for it.	BTL 1	Remembering
5.	What are the basic elements used for modeling mechanical translational system?	BTL 1	Remembering
6.	List the basic elements for modeling in mechanical rotational system.	BTL 1	Remembering
7.	Distinguish the terms sink and source.	BTL 2	Understanding
8.	Discuss any 2- applications of synchro.	BTL 2	Understanding
9.	Describe the characteristics of negative feedback in control systems.	BTL 2	Understanding
10.	Discuss the terms (i) Signal Flow Graph (ii) Non-touching loop.	BTL 2	Understanding
11.	Illustrate the terms (i) Block Diagram Reduction (ii) Mason;s Signal Flow Graph Method.	BTL 3	Applying
12.	Draw the electrical analog of a thermometer with neat diagram.	BTL 3	Applying
13.	Illustrate the terms (i) Path (ii) Forward Path (iii) Loop (iv) Non-touching Loop.	BTL 3	Applying
14.	Compare Signal Flow Graph approach with block diagram reduction technique of determining transfer function.	BTL 4	Analyzing
15.	Define open loop and closed loop system.	BTL 4	Analyzing
16.	Analyze the need of electrical zero position of a synchro transmitter.	BTL 4	Analyzing
17.	Explain the aligned position of a Synchro transmitter and synchro receiver.	BTL 5	Evaluating
18.	Can we use servomotor for position control? Support the answer with necessary details.	BTL 5	Evaluating
19.	Create the expression for Masons gain formula to find the system transfer	BTL 6	Creating

	function.		
20.	Formulate the force balance equation for ideal dash pot and ideal spring.	BTL 6	Creating
	PART – B		
1.	(i) Compare the open and closed loop control systems how it is distinguished with closed loop system. (6) (ii) Write the differential equations governing the mechanical rotational system as shown in Fig. . (7) 	BTL4	Analyzing
2.	(i) Compose the given block diagram shown in fig to signal flow graph and determine the closed loop transfer function C(s)/R(s). (8)  (ii) Differentiate DC and AC Servo Motor. (5)	BTL 6	Creating
3.	(i) Explain open loop and closed loop control systems with examples. (6) (ii) Derive the transfer function of an armature controlled DC Servo Motor. (7)	BTL 4	Analyzing
4.	Find the transfer function $y_2(s)$ / f(s) as shown in Fig. . (13) 	BTL 3	Applying
5.	(i) With neat diagrams, Discuss the working of AC Servo Motor. (6) (ii) Estimate the Transfer function of field Controlled DC Servo Motor. (7)	BTL2 BTL 2	Understanding Understanding

6.	Calculate the transfer function $Y_2(S)/F(S)$ for the given mathematical model. (13)	BTL 3	Applying
7.	Identify the overall gain C(S) / R(S) for the signal flow graph shown below. (13)  	BTL 1	Remembering
8.	(i) Arrange the differential equation for the Mechanical system as shown in Fig. .And also find the transfer function $X_2(S)/F(S)$. (13)  	BTL 4	Analyzing
9.	(i) Develop the transfer function $X_5(S)/X_1(S)$ using Mason's Gain formula for the system given.  (ii) Describe the construction and working principle of Synchro with neat sketch.(7+6)	BTL 6 BTL 1	Creating Remembering

10.	Formulate the transfer function for the block diagram shown in Fig. .. (i) using the Block diagram Reduction Technique. (ii) using Mason's Gain Formula. (7+6) 	BTL 6	Creating
11.	(i) Develop the transfer function of AC Servo Motor. (7) (ii) With neat diagram, explain the working principle of Field Controlled DC Servo Motor. (6)	BTL 6 BTL 5	Creating Evaluating
12.	(i) Illustrate the Transfer Function of Thermal system consists of a thermometer inserted in a liquid bath. (6) (ii) Compare DC Motor and DC Servo Motor and list out the applications of DC Servo Motor. (7)	BTL 3 BTL 4	Applying Analyzing
13.	(i) Describe the Mathematical Modelling of fundamental component of Mechanical Rotational System. (6) (ii) Describe how a Synchro works as error detector with neat diagram. (7)	BTL 1 BTL 1	Remembering Remembering
14.	What is meant by Servo mechanism? Explain the construction, working and also obtain the mathematical expression for (i) DC Servo Motor (ii) AC Servo Motor. (13)	BTL 5	Evaluating
	PART – C		
1.	Identify and obtain the electrical current analogy for the Mechanical system as shown in Fig. and also draw the circuit diagram. (15) 	BTL 1	Remembering
2.	(i) What is meant by Synchros ? Explain the following parts of Synchros (i) Syncro Transmitter (ii) Synchro Receiver (iii) Error detector (iv) Position Control applications with suitable diagram for each. (15)	BTL 5	Evaluating

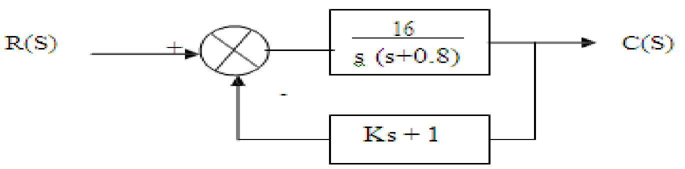
3.	In block diagram reduction explain the following terms(i) Block diagram (ii) Error Detector (iii) Take off Point (iv) Forward Path (v) Feedback path. And also express the rules for block diagram technique with suitable tabulation. (15)	BTL 2	Understanding
4.	(i)Create the Mathematical Model for (i) Mechanical Translational System (ii) Mechanical Rotational System (iii) Series RLC Circuit (iv) Parallel RLC Circuit with suitable diagram and expression. (15)	BTL 6	Creating

UNIT II - TIME RESPONSE

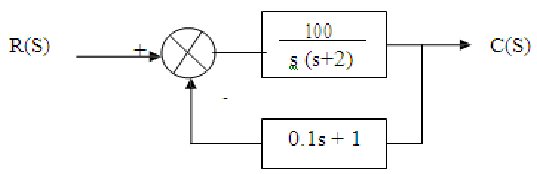
Time response – Time domain specifications – Types of test input – I and II order system response – Error coefficients – Generalized error series – Steady state error – Root locus construction- Effects of P, PI, PID modes of feedback control –Time response analysis.

PART - A

Q.No.	Questions	BT	Competence
1.	For the system described by $\frac{C(S)}{R(S)} = \frac{16}{(S^2 + 8S + 16)}$ Show the nature of the time response.	BTL 3	Applying
2.	Classify the time domain specifications.	BTL 3	Applying
3.	Define Delay time, Rise time, Peak time.	BTL 1	Remembering
4.	Define Step, Ramp & Parabolic signal	BTL 1	Remembering
5.	Calculate the acceleration error coefficient for $\frac{C(S)}{R(S)} = \frac{K(1+S)(1+2S)}{S^2(S^2+4S+20)}$	BTL3	Applying
6.	Evaluate the type and order of the system. $G(S) = \frac{K}{S(TS+1)}$	BTL 5	Evaluating
7.	How is a system classified depending on the value of damping?	BTL 2	Understanding
8.	Give the type and order of the following system. $G(S)H(S) = \frac{200}{(S^2 + 20S + 200)}$	BTL 2	Understanding
9.	What is steady state error? Mention the 3-different static error constants.	BTL 2	Understanding
10.	Distinguish between type and order of the system.	BTL 4	Applying
11.	List the drawback of static coefficients.	BTL 1	Remembering
12.	Give the relation between static and dynamic error coefficients.	BTL 1	Remembering
13.	Explain the need for a controller and different types of controller.	BTL 5	Evaluating
14.	State the basic properties of root locus.	BTL 1	Remembering
15.	Give the transfer function G(s) of a PID Controller.	BTL 2	Understanding

16.	What is the effect on system performance when a Proportional Controller is used in a system?.	BTL 6	Creating
17.	Infer why derivative controller is not separately used in control systems.	BTL 4	Analyzing
18.	Explain about the PI Controller.	BTL 4	Analyzing
19.	Express the PID Controller Equation.	BTL 2	Understanding
20.	Generalize the effect of PI Controller on the system performance.	BTL 6	Creating
	PART - B		
1.	i) Outline the time response of first order system when it is subjected to a unit step input. (8) ii) Determine the response of the unity feed back system whose open loop transfer function $G(S) = \frac{4}{S(S+5)}$ and when the input is unit step. (5)	BTL 2	Understanding
2.	Derive the expressions for second order system for underdamped case and when the unit is step input. (13)	BTL 1	Remembering
3.	(i) The open loop transfer function of a unity feedback system is given by $G(S) = \frac{1}{S(S+1)}$ The input to the system is described by r(t)=4+6t.Find the generalised error coefficient and steady state error. (6) (ii) For a unity feedback control system the open loop transfer function is given by $G(S) = \frac{10(S+2)}{S^2(S+5)}$ (a) Find the position ,velocity and acceleration error co-efficients. (b) Also find steady state error when the input is $R(S) = \frac{3}{S} - \frac{2}{S^2} + \frac{1}{3S^3}$ (7)	BTL 4	Analyzing
4.	(i) Measurements conducted on a Servomechanism show the system response to be c(t)=1+0.2 $\hat{e}^{-60t}$ -1.2 $\hat{e}^{-10t}$ when subjected to a unit step. Give the expression for closed loop transfer function. (6) (ii) What is the response c(t) to the unit step input. Given that ς =0.5.and also calculate rise time, peak time, Maximum overshoot and settling time.  (7)	BTL 4	Analyzing

5.	(i) The open loop transfer function of a unity feedback system is given by $G(S) = \frac{K}{S(TS+1)}$ where K and T are positive constants. By what factor should the amplifier gain reduced so that the peak overshoot of unit step response of the closed loop system is reduced from 75% to 25%. (7) (ii) For a closed loop system with $G(S) = \frac{1}{(1+S)}$ and H(S) =5 calculate the generalized error coefficients and find error. (6)	BTL 3	Applying
6.	Evaluate the expression for dynamic error coefficients of the following system $G(S) = \frac{10}{S(S+1)}$ (13)	BTL 1	Remembering
7.	A unity feedback system is characterised by an open loop transfer function $G(S) = \frac{K}{S(S+10)}$. Analyse and determine the gain K so that the system will have a damping ratio of 0.5. For this value of K determine settling time, peak overshoot and time to peak over shoot for a unit step input. (13)	BTL 4	Analyzing
8.	Find the static error coefficients for a system whose transfer function is $G(S)H(S) = \frac{10}{S(1+S)(1+2S)}$ .And also find the steady state error for r(t)=1+ t + t^2/2. (13)	BTL 5	Evaluating
9.	Develop the time response of a typical under damped second order system for a unit step input. (13)	BTL 1	Remembering
10.	Draw the root locus of the following system. $G(S)H(S) = \frac{K}{S(S+1)(S+2))}$ (13)	BTL 6	Creating
11.	(i) Sketch the root locus of the system whose open loop transfer function is $G(S) = \frac{K}{S(S+2)(S+4)}$. Find the value of K so that damping ratio is 0.5. (7) (ii) A unity feedback system has an amplifier with gain K_A=10 and gain ratio $G(S) = \frac{1}{S(S+2)}$ in the feed forward path. A derivative feedback,H(S)=S K_O is introduced as a minor loop around(s).Estimate the derivative feedback constant,K_O ,so that the system damping factor is 0.6. (6)	BTL 2	Understanding
12.	(i) Explain the rules to construct root locus of a system. (6) (ii) With a neat diagram explain the effect of PD Controller in detail. (7)	BTL 2	Understanding
13.	Explain the effect by adding P,PI, PD and PID Controllers in feedback control systems. (13)	BTL 1	Remembering

14.	(i) For a servomechanisms with open loop transfer function $G(S) = \frac{10}{S(S+2)(S+3)}$ .What type of input signal gives constant steady state error and calculate its value. (7) (ii) Compute the static error coefficients for a system whose $G(S) = \frac{10}{S(1+S)(1+2S)}$ and also find the steady state error forr(t)=1+ t + $t^2/2$.(6)	BTL 3	Applying
PART - C			
1.	Evaluate the expression for dynamic error coefficients of the following system $G(S) = \frac{10}{S(1+S)}$ (15)	BTL 5	Evaluating
2.	(i) The overall transfer function of a control system is given by $\frac{C(S)}{R(S)} = \frac{16}{(S^2+1.6S+16)}$ .It is desired that the damping ratio is 0.8.Determine the derivative rate feedback constant Ki and compare rise time, peak time, maximum overshoot and steady state error for unit ramp input function without and with derivative feedback control. (9) (ii) Compare P,I and D Controller. (6)	BTL 4	Analyzing
3.	Draw the root locus for a system is given by $G(S) = \frac{K(S+1)}{S(S^2+5S+20)}$. (15)	BTL 6	Creating
4.	A positional control system with velocity feedback as shown in fig. Give the response of the system for unit step input.  (15)	BTL 6	Creating

UNIT III FREQUENCY RESPONSE			
Frequency response – Bode plot – Polar plot – Determination of closed loop response from open loop response - Correlation between frequency domain and time domain specifications- Effect of Lag, Lead and Lag-Lead compensation on Frequency response- Analysis.			
PART A			
Q.No.	**Questions**	**BTL Level**	**Domain**
1.	Define the terms (i) Phase margin (ii) Gain margin (iii) Gain Cross-over frequency (iv) Phase Cross-over Frequency.	BTL 1	Remembering
2.	Give the advantages of Frequency response analysis.	BTL 1	Remembering

3.	Identify for +20db/sec slope change in Bode Plot.	BTL 1	Remembering
4.	Define the terms: Resonant peak and Resonant frequency.	BTL 1	Remembering
5.	Why is frequency response analysis important in control applications?	BTL 1	Remembering
6.	Define the following methods of frequency response plot. (i) Bode Plot (ii) Polar Plot (iii) Nyquist Plot (iv) Nichol's Chart.	BTL 1	Remembering
7.	What is starting and ending point of a polar plot identified for the system. Explain with suitable diagram.	BTL 2	Understanding
8.	Describe the different frequency domain specifications.	BTL 2	Understanding
9.	Mention the uses of Nichol's Chart.	BTL	Understanding
10.	Express the relationship between speed and frequency.	BTL 2	Understanding
11.	Draw the polar plot of $G(S) = \frac{1}{(1+TS)}$	BTL 3	Applying
12.	Find the corner frequency of $G(S) = \frac{10}{S(1+0.5S)}$	BTL 3	Applying
13.	Draw the circuit of lead compensator and its pole zero diagram.	BTL 3	Analyzing
14.	Draw the approximate polar plot for a Type 0 second order system.	BTL 3	Applying
15.	Compare Lead. Lag and Lead-Lag Compensator with suitable example.	BTL 4	Analyzing
16.	Compare the need for Lag/Lag-Lead Compensation.	BTL 4	Analyzing
17.	Evaluate the Frequency domain specification of a Second order system when closed loop transfer function is given by $\frac{C(S)}{R(S)} = \frac{64}{(S^2+10S+64)}$	BTL 5	Evaluating
18.	Evaluate the term Corner frequency.	BTL 5	Evaluating
19.	Create the suitable diagram for the (i) Starting Point (ii) Ending point of Polar Plot for identify the system.	BTL 6	Creating
20.	Formulate the expression for (i) Resonant Peak (ii) Resonant Frequency.	BTL 6	Creating
PART – B			
1.	(i) Describe the use of Nichol's chart to obtain closed loop frequency response from open loop frequency response of a unity feedback system. (7)	BTL 1	Remembering

	(ii) Describe the correlations between time and frequency domain specifications. (6)		
2.	With Mathematical expression define the following Frequency Domain specifications (i) Gain Margin (ii) Phase Margin (iii) Gain Cross over Frequency (iv) Phase Cross over Frequency (v) Resonant Peak (vi) Resonant Frequency (vii) Bandwidth. (13)	BTL 1	Remembering
3.	Draw and show the Bode plot for the open loop transfer function of a unity feedback system $G(S) = \frac{10(S+3)}{S(S+2)(S^2+3S+25)}$ and Determine : (i) Gain Margin (ii) Phase Margin (iii) Gain Cross Over Frequency (iv) Phase Cross Over Frequency. (13)	BTL 3	Applying
4.	The Open Loop Transfer Function $G(S) = \frac{K}{S(1+0.5S)(1+4S)}$ Determine the values manually calculate (i) Gain Margin (ii) Phase Margin (iii) Gain Cross Over Frequency (iv) Phase Cross Over Frequency(v) Stability range K. (13)	BTL 3	Applying
5.	What is meant by Compensator? Summarize the following effects of compensator (i) Lead Compensator (ii) Lag Compensator (iii) Lead-Lag Compensator withy suitable transfer function. (13)	BTL 2	Understanding
6.	Sketch the Bode plot and hence find Gain cross over frequency, Phase cross over frequency, Gain margin and Phase margin for the function $G(S) = \frac{10(S+3)}{S(S+2)(S^2+4S+100)}$ (13)	BTL 3	Applying
7.	Develop the Bode plot for the open loop transfer function of a unity feedback system $G(S) = \frac{10}{S(S+2)(S+6)}$ and Determine: (i) Gain Margin (ii) Phase Margin (iii) Gain Cross Over Frequency (iv) Phase Cross Over Frequency. (13)	BTL 6	Creating
8.	Draw and show the polar plot of the system open loop transfer function with unity feedback system given by $G(S) = \frac{10}{S(S+1)(S+4)}$ Determine the phase and gain margin. (13)	BTL 3	Applying
9.	The given transfer function $\frac{C(S)}{R(S)} = \frac{10(S+2)}{(S^2+4S+5)}$. Evaluate (i) Magnitude (ii) Phase Angle (iii) Band width. (13)	BTL 5	Evaluating

10.	The Open Loop Transfer Function $G(S)=\dfrac{K}{(S+1)^3}$. Determine and Calculate the (i) Gain Margin (ii) Phase Margin (iii) Gain Cross Over Frequency (iv) Phase Cross Over Frequency (v) Stability range K. (13)	BTL 3	Applying
11.	Draw the Polar plot for the open loop transfer function of a unity feedback system $G(S)=\dfrac{10(S+3)}{S(S+2)(S^2+3S+25)}$ and Determine and Point out : (i) Gain Margin (ii) Phase Margin (iii) Stability. (13)	BTL 4	Analyzing
12.	Write the Estimation Procedure for Polar Plot and obtaining (i) Gain Margin (ii) Phase Margin. And also point out the stability of the system. (13)	BTL 4	Analyzing
13.	Sketch the polar plot for the following transfer function and find Gain cross over frequency, Phase cross over frequency, Gain margin and Phase margin for $G(S)=\dfrac{400}{S(S+2)(S+10)}$ (13)	BTL 5	Evaluating
14.	The Second Order System has the closed loop transfer function $\dfrac{C(S)}{R(S)}=\dfrac{8}{(S^2+4S+8)}$. Calculate the following Frequency Domain specifications (i) Resonant Peak (ii) Resonant Frequency (iii) Bandwidth. (13)	BTL 3	Applying
PART C			
1.	(i) Evaluate the expression for(i) Resonant Peak (ii) Resonant Frequency (iii) Bandwidth. (8) (ii) Obtain the expression for the correlation between time domain and frequency domain analysis. (7)	BTL 5	Evaluating
2.	Develop the Polar plot sketch approximation manually and also write the expression for each (i)Type 0 and Order 1 (ii) Type 1 and Order 2 (iii)Type 2 and Order 4 (iv)Type 2 and Order 5. (15)	BTL 6	Creating
3.	Construct Polar plot for the system $G(S)=\dfrac{5(S+10)}{S(S+2)(S+6)}$ whose open loop transfer function is given below and Calculate (i)Gain margin (ii) Phase Margin (iii) Gain Cross-over Frequency (iv)	BTL 3	Applying

	Phase Cross over Frequency (v) Stability. (15)		
4.	(i) Evaluate the correlations between time and frequency domain specifications. (7) (ii) With Mathematical expression define the following Frequency Domain specifications (i) Gain Margin (ii) Phase Margin (iii) Gain Cross over Frequency (iv) Phase Cross over Frequency. (8)	BTL 5 BTL 1	Evaluating Remembering

UNIT IV - STABILITY AND COMPENSATOR DESIGN			
Characteristics equation – Routh Hurwitz criterion – Nyquist stability criterion- Performance criteria – Lag, lead and lag-lead networks – Lag/Lead compensator design using bode plots.			
PART - A			
Q.No	**Questions**	**BT Level**	**Competence**
1.	Illustrate Nyquist stability criterion. And also write the formula for stability analysis..	BTL 3	Applying
2.	Define BIBO Stability.	BTL 1	Remembering
3.	Express Routh's Hurwitz criterion.	BTL 2	Understanding
4.	How are the roots of the characteristic equation of a system related to stability?	BTL 2	Understanding
5.	Solve and find the range of K for closed loop stable behaviour of the system with characteristic equation $4S^4+24S^3+44S^2+24S+K$ using Routh Hurwitz stability criterion.	BTL 3	Applying
6.	Point out the techniques used for determination of closed loop response from open loop response.	BTL 4	Analyzing
7.	What are two motions of system stability to be satisfied for a linear time-invariant system to be stable?	BTL 2	Understanding
8.	Judge what is dominant pole.	BTL 5	Evaluating
9.	State the necessary and sufficient condition for stability.	BTL 4	Analyzing
10.	What is characteristic equation?	BTL 1	Remembering
11.	List the advantages and disadvantages of phase lag network.	BTL-1	Remembering
12.	Summarize the effect of adding open loop poles and zero on the nature of the root locus and on system?	BTL 5	Evaluating
13.	Define compensator and list the types of compensators.	BTL 1	Remembering

14.	Quote the need of compensator	BTL 1	Remembering
15.	Formulate the transfer function of lag compensator and draw the electric lag network and its pole-zero plot.	BTL 6	Creating
16.	Point out the properties of Lag compensator	BTL 4	Analyzing
17.	What is meant by Lead compensator? Give example for it.	BTL 2	Understanding
18.	Formulate the transfer function of lead compensator and draw and show pole-zero plot.	BTL 6	Creating
19.	Differentiate between Gain margin and Phase margin.	BTL 3	Applying
20.	Define the terms (i) Asymptotic stable (ii) Marginally stable.	BTL 1	Remembering
PART - B			
1.	Construct Routh's array and estimate the stability analysis of the system represented by the characteristic equation and comment on the location of roots. (i) $s^5 + s^4 + 2s^3 + 2s^2 + 3s + 5 = 0$ (6) (ii) $s^7 + 5s^6 + 9s^5 + 9s^4 + 4s^3 + 20s^2 + 36s + 36 = 0$ (7)	BTL 2	Understanding
2.	(i) Use R-H criterion to determine the location of the roots and stability for the system represented by characteristic equationþ $s^5 + 4s^4 + 8s^3 + 8s^2 + 7s + 4 = 0$. (6) (ii) Write the procedure for the design of Lag compensator using Bode plot. (7)	BTL 2	Understanding
3.	(i) Obtain Routh's array for the system whose characteristic polynomial equation is $s^6 + 2s^5 + 8s^4 + 12s^3 + 20s^2 + 16s + 16 = 0$ Test the stability. (6) (ii) Define Nyquist stability criterion and explain the different situations of it. (7)	BTL 1	Remembering
4.	Draw the Nyquist plot for the system whose open loop transfer function $G(S)H(S) = \frac{K}{S(S+2)(S+10)}$ Determine the range of K for which closed loop system is stable. (13)	BTL 2	Understanding
5.	Determine the stability of closed loop system by Nyquist stability criterion, whose open loop transfer function is given by, $G(S)H(S) = \frac{S+2}{(S+1)(S-1)}$ (13)	BTL-1	Remembering

6.	Use the routh stability criterion,determine the range of K for stability of unity feedback system whose open loop transfer function is $G(S) = \dfrac{K}{S(S+1)(S+2)}$. (10) (ii)State Routh stability criterion,.If the system is conditionally stable, solve and point out the range of K for which the system is stable. (3)	BTL-4	Analyzing
7.	(i) Test the stability for the system with characteristic equation $s^3 + 5s^2 + 6s + 30 = 0$ using Routh's Hurwitz. (6) (ii) Construct Routh's array and point out the stability of the system whose characteristic equation is $s^6 + 2s^5 + 8s^4 + 12s^3 205s^2 + 16s + 16 = 0$. (7)	BTL-5	Evaluating
8.	The open loop transfer function of the uncompensated system is $G(S) = \dfrac{5}{S(S+2)}$. Design a suitable compensator for the system so that the static velocity error constant K_v is 20sec^{-1}, the phase margin is atleast 55^0 and the gain margin is atleast 12dB. (13)	BTL-4	Analyzing
9.	(i) Describe the procedure for designing of a lag compensator. (6) (ii) Describe the procedure for designing of a lag-lead compensator. (7)	BTL-1	Remembeing
10.	Design a Phase Lead compensator for the unity feedback transfer function $G(S) = \dfrac{K}{S(S+2)}$ has specifications : a. Phase Margin$\geq 55^0$ b. The steady state error for ramp input is less than or equal to 0.33 and illustrate whether the design is acceptable or not. (Assume K=1). (13)	BTL-3	Applying
11.	Design a Lead compensator for the unity feedback transfer function with open loop transfer function $G(S) = \dfrac{K}{S(S+1)(S+5)}$ to satisfy the following specifications: a. $K_v \geq 50$. Phase Margin$\geq 20^0$. Illustrate whether the design is acceptable or not. (13)	BTL-3	Appling
12.	Design a Phase Lag compensator for the unity feedback transfer function $G(S) = \dfrac{5}{S(S+1)(S+4)}$ has specifications a. Phase Margin$\geq 40^0$ b. The steady state error for ramp input is less than or equal to 0.2 and check whether the design is acceptable or not. (13)	BTL-6	Creating

13.	Explain the procedure of Lag Compensator using bode plot with an example. (13)	BTL-1	Remembering
14.	(i) Explain the different types of compensation techniques. (6) (ii) A unity feedback system has the open loop transfer function $G(S) = \frac{K}{S(S+2)}$ .Design and Point out a lead compensator for the system to achieve the following specifications Velocity error constant $K_v \geq$ 12 sec^{-1} , Phase Margin$\geq 45^0$. (7)	BTL-4	Analyzing
PART - C			
1.	The open loop transfer function of a unity feedback control system is given by $G(S) = \frac{K}{(S+2)(S+4)(S^2+6S+25)}$ By applying Routh criterion, discuss the stability of the closed loop system as a function of K. Determine the values of K which will cause sustained oscillations in the closed loop system. What are the corresponding oscillation frequencies? (13)	BTL-4	Analyzing
2.	For a given system $G(S) = \frac{K}{S(S+1)(S+2)}$ Design a suitable lag-lead compensator to give Velocity error constant K_v=10 sec^{-1}, Phase Margin$\geq 50^0$,Gain margin $\geq$ 10dB. (15)	BTL-6	Creating
3.	Realize the basic compensators using electrical network and obtain the transfer function, (15)	BTL-6	Creating
4.	Construct the Nyquist plot for the system whose open loop transfer function is given by $G(S) = \frac{K(1+S)^2}{S^3}$.Find the range of K for stability. (15)	BTL-6	Creating

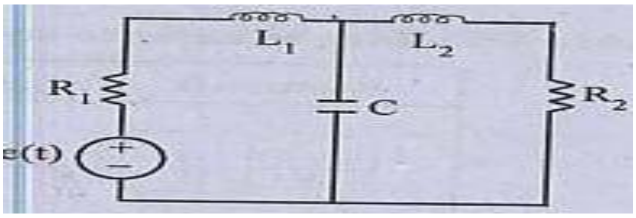
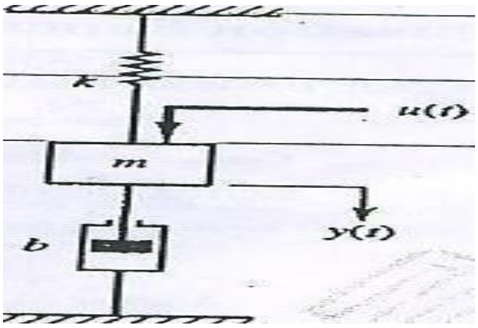
UNIT V STATE VARIABLE ANALYSIS

Concept of state variables – State models for linear and time invariant Systems – Solution of state and output equation in controllable canonical form – Concepts of controllability and observability – Effect of state feedback.

PART A

Q.No.	**Questions**	**BTL Level**	**Domain**
1.	Point out the drawbacks in transfer function model analysis.	BTL 4	Analyzing

2.	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] $\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$ Point out whether the given is controllable.	BTL 4	Analyzing
3.	Give the general form of the state space model for continuous system and also draw the state diagram.	BTL 2	Understanding
4.	Define the following terms such as (i) State (ii) State Variable (iii) State Vector (iv) State Space Model.	BTL 1	Remembering
5.	What is the state transition matrix? List any two methods for finding state transition matrix.	BTL 1	Remembering
6.	Formulate the state space model with state diagram for observable canonical form.	BTL 6	Creating
7.	Consider a system whose transfer function is given by Y(S)/U(S) = 10(S+1)/S^3+6s^2+5s+10 . Solve and obtain a state model for this system.	BTL 3	Applying
8.	Obtain the state space model for the given differential equation $\frac{d^3Y}{dt^2} + 6\frac{d^2Y}{dt^2} + 11\frac{dY}{dt} + 6Y = U(t)$ Evaluate the transfer function model.	BTL 5	Evaluating
9.	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.	BTL 5	Evaluating
10.	Express the homogeneous and non homogeneous state equation.	BTL 2	Understanding
11.	List the advantages of state space analysis.	BTL 1	Remembering
12.	Illustrate the condition for Controllability and Observability by Kalman's method.	BTL 3	Applying
13.	Express the necessary condition to be satisfied for the design of state observer? Also Write the Ackermann's formula to find the state observer gain matrix,G.	BTL 2	Understanding
14.	Write and explain the Formula in which the general form of state	BTL 4	Analyzing

	space model into transfer functional approach.		
15.	Illustrate Cayley-Hamilton theorem.	BTL 3	Applying
16.	Define state trajectory.	BTL 1	Remembering
17.	Define (i) Controllability of a system. (ii) Observability of the system.	BTL 1	Remembering
18.	Express any 2-methods for the conversion of transfer functional model into state space model.	BTL 2	Understanding
19.	Formulate the state space model with state diagram for controllable canonical form.	BTL 6	Creating
20.	List the applications of state space model for the different system.	BTL 1	Remembering
	PART – B		
1.	Obtain and examine the state model of the following electrical system. (13) 	BTL 1	Remembering
2.	Obtain and examine 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 1	Remembering
3.	The given state space model of the system $\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix}=\begin{bmatrix}0 & 1 & 1\\ 0 & 0 & 1\\ -1 & -5 & -6\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}+\begin{bmatrix}0\\ 0\\ 10\end{bmatrix}U$;y=[1 0 0] $\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}$ Check whether the given is controllable and observable or not. And also Point out duality by Kalman's approach and Gilbert's method. (13)	BTL 4	Analyzing

4.	Consider a system with state space model is given below. $\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix} = \begin{bmatrix}0 & 1 & 2\\ 0 & 0 & 1\\ -1 & -2 & -3\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix} + \begin{bmatrix}0\\ 0\\ 4\end{bmatrix}U$; y=[2 -4 0] $\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}$ Point out that the system is observable and controllable. (13)	BTL 4	Analyzing
5.	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 $\mu_1 = -5$; $\mu_2 = -5$. (13)	BTL 2	Understanding
6.	Examine and convert the following transfer function for the state space model $\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix} = \begin{bmatrix}0 & 1\\ -3 & -2\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix} + \begin{bmatrix}0\\ 2\end{bmatrix}U$; y=[1 0] $\begin{bmatrix}x_1\\ x_2\end{bmatrix}$ $\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix} = \begin{bmatrix}-5 & -1\\ 3 & -1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix} + \begin{bmatrix}2\\ 5\end{bmatrix}U$; y=[1 2] $\begin{bmatrix}x_1\\ x_2\end{bmatrix}$ (13)	BTL 1	Remembering
7.	Explain the concept of controllability and observability by Kalman's and Gilbert's method . (13)	BTL 2	Understanding
8.	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 $A = \begin{bmatrix}0 & 1\\ -12 & 7\end{bmatrix}$ (13)	BTL 3	Applying
9.	Determine the canonical state model of the system whose transfer function $T(S) = \dfrac{2(S+50)}{(S+2)(S+3)(S+4)}$ (13)	BTL 4	Analyzing
10.	Consider a system whose transfer function is given by $\dfrac{Y(S)}{U(S)} = \dfrac{10(S+1)}{(S^3+6S^2+5S+10)}$ Evaluate the state model for the system (i) by Block diagram reduction (ii) Signal flow graph Method. (13)	BTL 5	Evaluating
11.	Formulate the expression for the state space model for the	BTL 6	Creating

	continuous system and also draw the state diagram for it. (13)		
12.	Obtain the complete solution of non homogeneous state equation using time domain method. (13)	BTL 6	Creating
13.	Obtain the following 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. (13)	BTL 3	Applying
14.	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.(13)	BTL 2	Understanding
	PART – C		
1.	The state space model $\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix}=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -1 & -5 & -6\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}+\begin{bmatrix}0\\ 0\\ 1\end{bmatrix}U$; $\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}$ The desired poles are S=-2+4j,-2-j4,-1.0 with state feedback control law U=KX. Estimate the state feedback gain matrix K. (15)	BTL 5	Evaluating
2.	Develop the expression of (i) Controllability (ii) Observability concept by the following methods (i) Gilbert's Method (ii) Kalman's Method. (15)	BTL 6	Creating
3.	The state space model for the system is given $\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix}=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -1 & -5 & -6\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}+\begin{bmatrix}0\\ 0\\ 1\end{bmatrix}U$; $\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}$ y=[1 0 0] $\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}$ Check and illustrate whether the given system is controllable and observable by any one of the method and check the duality of the system. (15)	BTL 3	Applying
4.	Consider a linear system described by the following transfer function, $\frac{Y(S)}{U(S)}=\frac{10}{S(S+1)(S+2)}$ .Design a feedback controller with a state feedback so that the closed loop poles are placed at -2,-1$\pm$ j1. (15)	BTL 5	Evaluating