SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

SRM Nagar, Kattankulathur – 603 203

DEPARTMENT OF

ELECTRONICS AND INSTRUMENTATION ENGINEERING

QUESTION BANK

V SEMESTER

1905504–CONTROL SYSTEMS

(Common to Department of Electrical and Electronics Engineering)

Regulation – 2019

Academic Year 2022 – 2023 (Odd)

Prepared by

Dr. S. Visalakshi, Professor and Head - EIE

Dr. S. Malathi, Assistant Professor (Sel.G) - EEE

SRMVALLIAMMAI ENGINEERING COLLEGE

SRM Nagar, Kattankulathur – 603 203.

DEPARTMENT OF ELECTRONICS AND INSTRUMENTATION ENGINEERING

QUESTION BANK

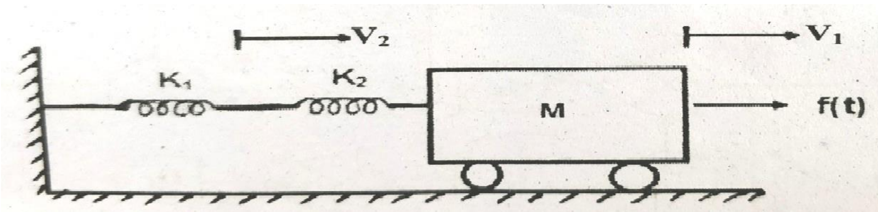
SUBJECT : 1905504 CONTROL SYSTEMS

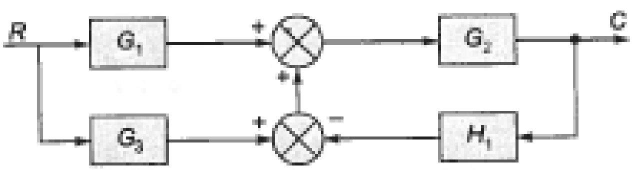
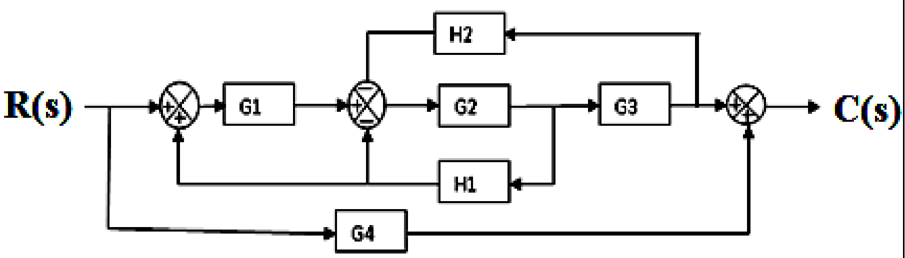
SEM / YEAR : V/ III

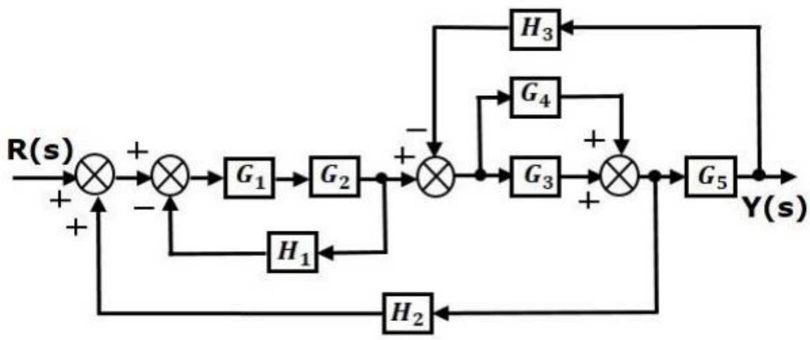
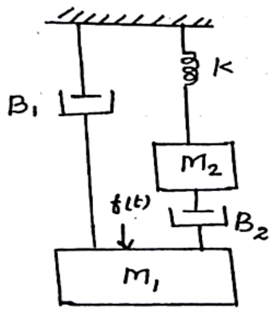
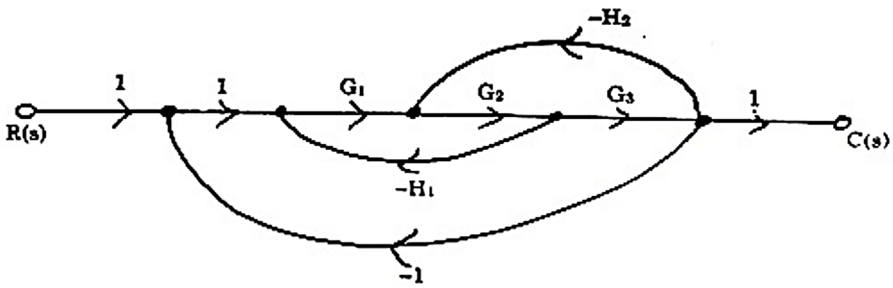
UNIT I - SYSTEMS AND REPRESENTATION

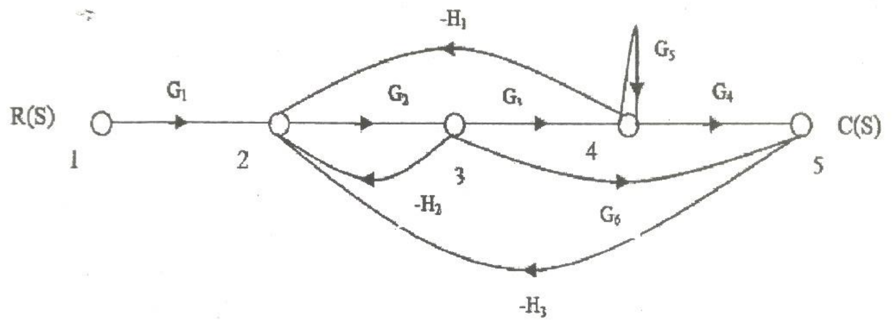
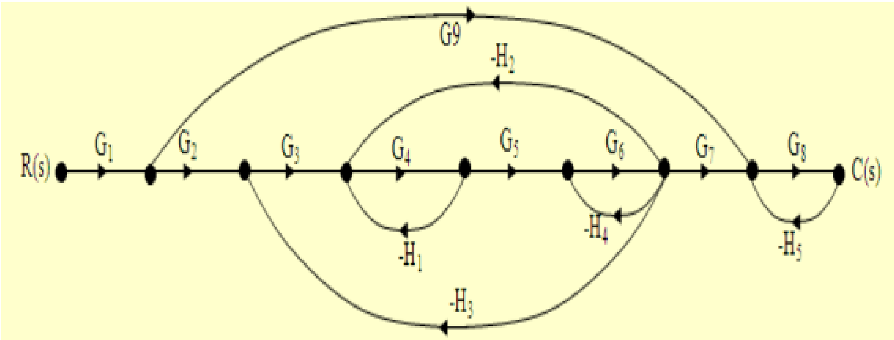
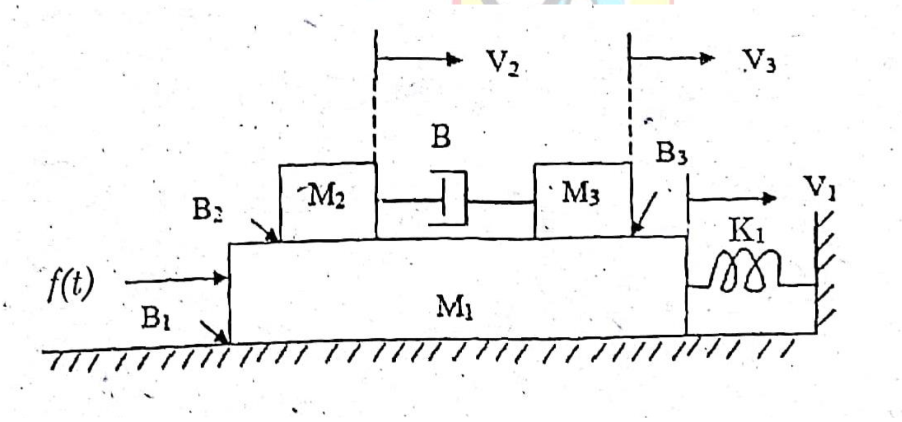
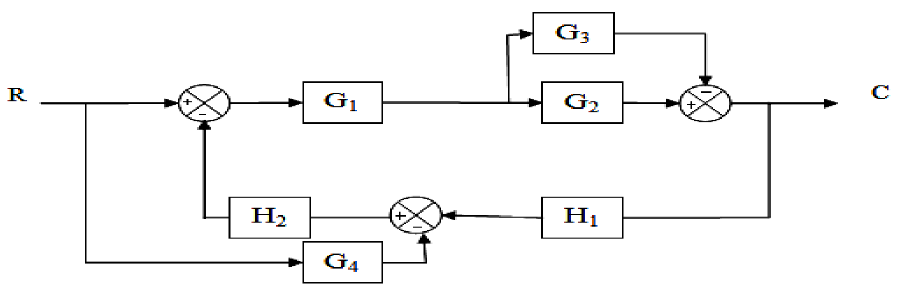
Basic elements in control systems: – Open and closed loop systems – Electrical analogy of mechanical and thermal systems – Transfer function, Synchros, – AC and DC servomotors – Block diagram reduction techniques – Signal flow graphs.

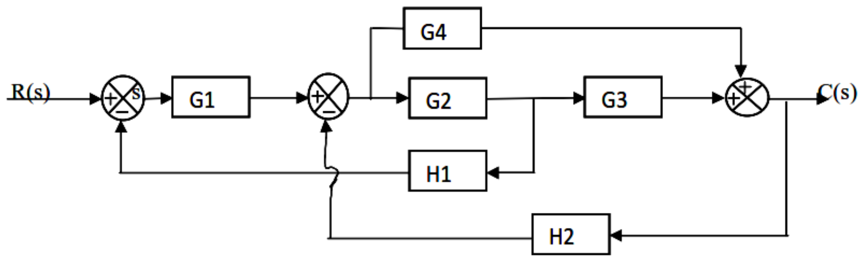
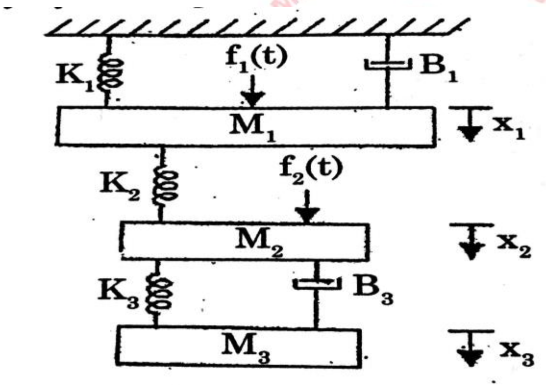
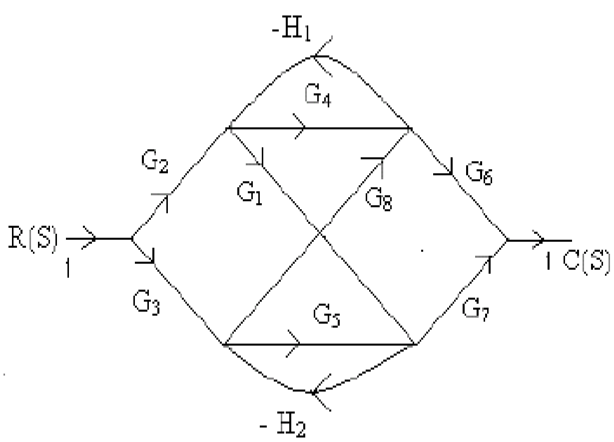
PART –A

Q.No	Questions	BT Level	Competence
1.	List the basic elements in control systems?	BTL 1	Remember
2.	What is the role of error detector in control system?	BTL 1	Remember
3.	Explain the principle of superposition and homogeneity.	BTL 2	Understand
4.	Classify open loop and closed loop system.	BTL 4	Analyze
5.	Infer the reason for preferring negative feedback control system.	BTL 2	Understand
6.	Classify the major types of control systems based on feedback.	BTL 2	Apply
7.	The open loop gain of a system increases by 25%. Identify the change in the closed loop gain assuming unity feedback.	BTL 3	Apply
8.	Determine the open loop DC gain of a unity feedback control system having closed loop transfer function as $(s+4)/(s^2+7s+13)$.	BTL 5	Evaluate
9.	Formulate the force balance equation for ideal dash pot and ideal spring element**.**	BTL 6	Create
10.	For the mechanical system shown in Fig. construct the corresponding Force- Voltage analogy circuit.  	BTL 3	Apply
11.	Explain the term thermal capacitance and thermal resistance	BTL 5	Evaluate
12.	Justify the electrically analogous to temperature in thermal flow system?	BTL 5	Evaluate

13.	List the parameters of the translational and rotational mechanical system	**BTL 1**	Remember
14.	Define transfer function.	**BTL 1**	Remember
15.	Analyse the need of electrical zero position in synchro transmitter.	**BTL 4**	Analyze
16.	Outline the applications of synchros.	**BTL 2**	Understand
17.	Compare AC Servomotor and DC Servomotor.	**BTL 2**	Understand
18.	Discuss how AC servomotor is controlled?	**BTL 6**	Create
19.	What is block diagram? State its components.	**BTL 1**	Remember
20.	What are the disadvantages of block diagram representation?	**BTL 1**	Remember
21.	Examine how the summing point and take off point are interchanged	**BTL 4**	Analyze
22.	Develop Masons gain formula to find the system transfer function.	**BTL 3**	Apply
23.	Compare Signal Flow Graph approach with block diagram reduction technique of determining transfer function.	**BTL 4**	Analyze
24.	Identify the following terminology (i) Path (ii) Forward Path (iii) Loop (iv) Non-touching Loop	**BTL 3**	Apply
	PART - B		
1.	**(i)** For the block diagram shown in figure. Determine the overall transfer function. **(6)** 	**BTL 2**	Understand
	(ii) Develop the transfer function of field Controlled DC servomotor and define transfer function. **(7)**	**BTL 2**	Understand
2.	For the block diagram shown in figure, **(i)** Simplify using Block Diagram Reduction Method. **(6)** **(ii)** Interpret Signal flow graph method and verify the transfer function obtained using block diagram reduction method. **(7)** 	**BTL 4** **BTL 4**	Analyze Analyze

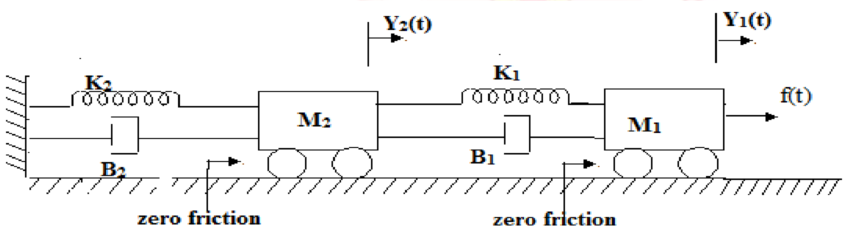
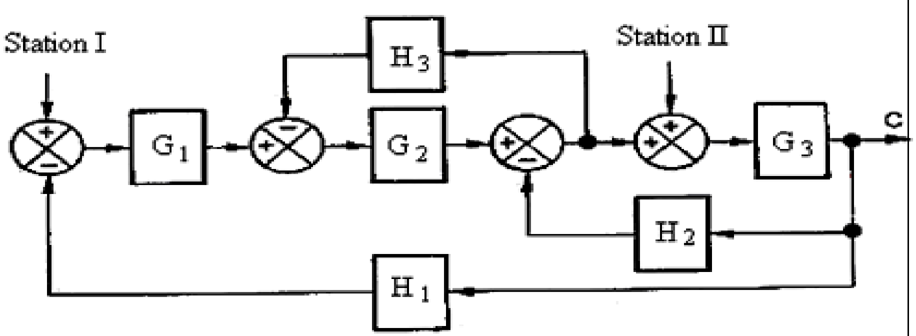
3.	Apply block diagram reduction rules and obtain the transfer function of the following system. **(13)** 	**BTL 3**	Apply
4.	**(i)** Draw the force-voltage analogy and force current analogy for the mechanical system shown in figure. **(7)** 	**BTL 1**	Remember
	(ii) Explain armature controlled DC servomotor with relevant block diagram. **(6)**	**BTL 1**	Remember
5.	**(i)** Solve the transfer function using Mason's Gain formula for the system whose signal flow graph is shown in figure. **(7)** 	**BTL3**	Apply
	(ii) Explain open loop and closed loop systems with suitable examples. **(6)**	**BTL 1**	Remember

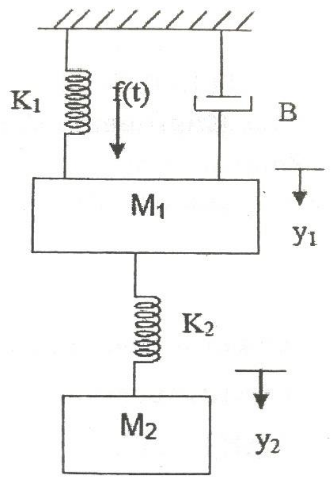
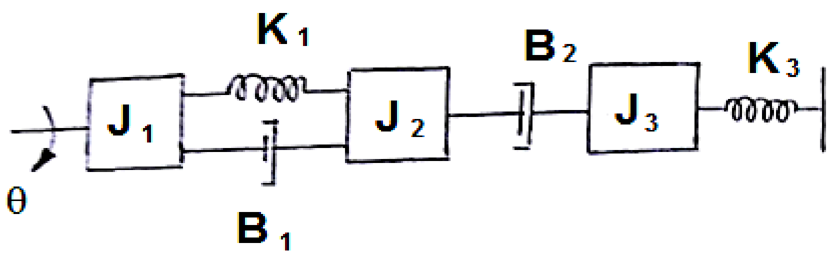
6.	Using Mason’s gain formula, find the overall gain C(s)/R(s) for the signal flow graph shown in figure. **(13)** 	**BTL 1**	Remember
7.	Analyze the given signal flow graph and obtain the transfer function C(s)/R(s). **(13)** 	**BTL 4**	Analyze
8.	Evaluate the transfer function of mechanical systems shown in the following figure. **(13)** 	**BTL 5**	Evaluate
9.	Develop the transfer function for the block diagram shown in fig. using **(i)** Block diagram reduction technique. **(6)** **(ii)** Mason’s Gain Formula. **(7)** 	**BTL 6**	Create

10.	**(i)** What the properties of signal flow graph. **(5)**	**BTL 1**	Remember
	(ii) List out of the rules followed in block diagram reduction technique**.** **(8)**	**BTL 1**	Remember
11.	Explain the procedure of deriving the transfer function C(s) / R(s) for the block diagram shown in figure using block diagram reduction technique. **(13)** 	**BTL 2**	Understand
12.	Write the differential equations governing the mechanical system shown in figure. Also draw the force voltage and force current analogous circuit and verify by writing mesh and node equations. **(13)** 	**BTL 2**	Understand
13.	Solve and find the overall gain of the system whose signal flow graph is shown in fig **(13)** 	**BTL 3**	Apply
14.	**(i)** Illustrate the transfer function of AC servo motor. **(7)**	**BTL 2**	Understand

	(ii) With neat diagram, summarize the working principle of field Controlled DC servo motor. **(6)**	**BTL 2**	Understand
15.	**(i)** Analyze the Transfer Function of thermal system consists of a thermometer inserted in a liquid bath. **(6)**	**BTL 4**	Analyze
	(ii) Compare DC motor and DC Servomotor and list out the applications of DC servomotor**.** **(7)**	**BTL 4**	Analyze
16.	**(i)** List out the assumptions made in ideal thermal system. **(3)**	**BTL 1**	Remember
	(ii) What are the basic elements of thermal system? **(2)**	**BTL 1**	Remember
	(iii) What are analogous system? Compare Mechanical and Electrical analogous system. **(8)**	**BTL 1**	Remember
17.	Explain the construction and operating principle of synchro transmitter with neat diagrams. **(13)**	**BT 5**	Understand

PART – C

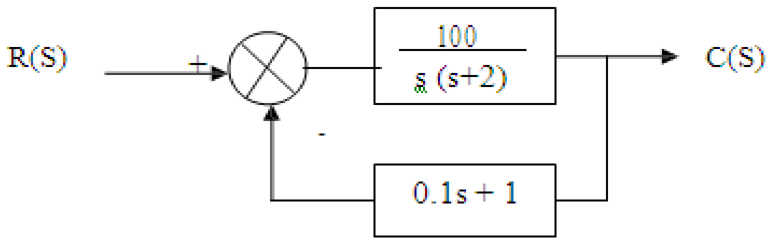
1.	Formulate the differential equations governing the mechanical translational system shown in fig. Draw the electrical equivalent analogy circuit. **(15)** 	**BTL 6**	Analyze
2.	For the system represented by block diagram shown in fig., Obtain the closed loop transfer function C(s) / R(s), when the input R(s) is applied instation I. **(15)** 	**BTL 5**	Evaluate
3.	Evaluate transfer function $y_2(s)$ / f(s). **(15)**	**BTL 5**	Evaluate

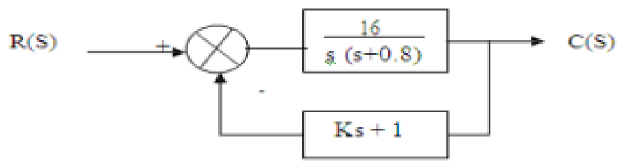
			
4.	Solve the given mechanical rotational system and write the differential equations governing the as shown in fig. Draw the both electrical analogous circuits. **(15)** 	**BTL 6**	Create
5.	i) Compare AC servomotor and DC servomotor. **(8)** ii) Compare the armature and field controlled operation DC servomotor **(7)**	**BTL 5**	Evaluate

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 Level**	**Competence**
1.	Define maximum peak overshoot.	**BTL 1**	Remember
2.	Assess the standard test signals employed for time domain studies.	**BTL 5**	Evaluate
3.	What is the type and order of the following system	**BTL 1**	Remember

	$\frac{C(S)}{R(S)} = \frac{10}{s^3(s^2+2s+1)}$		
4.	With a neat sketch, draw the time response of second order system, with all time response specifications.	**BTL 3**	Apply
5.	Infer the relation between static and dynamic error coefficients.	**BTL2**	Understand
6.	For a system by $\frac{C(S)}{R(S)} = \frac{16}{s^2+8s+16}$. Find the nature of the time response and justify.	**BTL 4**	Analyze
7.	How centroid of the asymptotes found in root locus technique?	**BTL 4**	Analyze
8.	The impulse response of a system is c (t) = $-te^{-t} + 2\ e^{-t}$ (t>0). Find its open loop transfer function.	**BTL 6**	Create
9.	Classify type and order of the system.	**BTL 2**	Understand
10.	List the standard test signals used in control system.	**BTL 1**	Remember
11.	Mention the effects of Proportional Integral (PI) controller.	**BTL 5**	Evaluate
12.	Compare between the steady state and transient response of the system.	**BTL 2**	Understand
13.	Explain steady state error.	**BTL 5**	Evaluate
14.	How is a system classified depending on the value of damping?	**BTL 4**	Analyze
15.	Define settling time.	**BTL 1**	Remember
16.	For servo mechanisms with open loop transfer function is given by G(s) = 1 / (s^2 + 2s + 3). Calculate position error and steady state error for a unit step input.	**BTL 3**	Apply
17.	The open loop transfer function of a unity feedback control system is given by G(s) = k/s(s+1). If gain k is increased to infinity, then damping ratio.	**BTL 2**	Understand
18.	What are the generalized error coefficients? How they are determined?	**BTL 1**	Remember
19.	The unit impulse response of second order system is (1/6) * $e^{-0.8t}$ sin (0.6t). Find the natural frequency.	**BTL 6**	Create
20.	The system function N(s) = V(s)/I(s) = (s+3)/(4s+5). The system is initially at rest. If the excitation I (t) is a unit step, which of the following is the final value?	**BTL 1**	Remember
21.	How location of poles is related to stability?	**BTL 3**	Apply
22.	Explain the three types of error constants?	**BTL 2**	Understand
23.	Identify the mathematical definitions of steady state error	**BTL 3**	Apply

	coefficients K_p,K_v,K_a.		
24.	List the drawbacks of static coefficients	**BTL 4**	Analyze
	PART – B		
1.	(i)Evaluate the unit step response of the following system. **(7)** $$\frac{C(S)}{R(S)} = \frac{10}{s^2+2s+10}$$	**BTL 5**	Evaluate
	(ii)A Unity feedback control system is characterized by open loop transfer function $G(s) = \frac{10}{s(s+2)}$. Calculate its time response for step input of 12 units. **(6)**	**BTL 5**	Evaluate
2.	Derive the expression for second order system for under damped case and when the input is unit step. **(13)**	**BTL 2**	Understand
3.	Derive the expression for the unit step response of following second order systems. **(7 + 6)** **(i)** Critically damped system **(ii)** Over damped system	**BTL 2**	Understand
4.	Derive Expressions for the following time domain specifications of second order under damped system due to unit step input. **(13)** **(i)** Rise time. **(ii)** Peak time. **(iii)** Delay time. **(iv)** Peak overshoot.	**BTL 2**	Understand
5.	The unity feedback system characterized by open loop transfer function $G(s) = \frac{K}{s(s+10)}$. Estimate the gain K such that damping ratio will be 0.5 and find time domain specifications for a unit step input. **(13)**	**BTL6**	Create
6.	i) For a unity feedback control system $G(s) = \frac{10(s+2)}{s^2(s+1)}$. Analyze the position, velocity and acceleration error constant. **(7)**	**BTL4**	Analyze
	ii)Explain the graphical and mathematical representation of following test signals (a) step input (b) Ramp Input (c) Parabolic input (d) Impulse input. Also point out the relationship between these test signals if any **(6)**	**BTL4**	Analyze
7.	A positional control system with velocity feedback is shown. Find	**BTL1**	Remember

	the response of the system for unit step input. **(13)** 		
8.	Construct the root locus for the system having **(13)** $G(s)=\frac{k(s+3)}{s(s+1)(s+2)(s+4)}$.	**BTL1**	Remember
9.	A unity feedback system us characterized by the open loop transfer function $G(s)=\frac{1}{s(0.5s+1)(0.2s+1)}$. (i) Write the closed loop transfer function C(s)/ R(s) (ii) Find damping factor, natural frequency of the system (iii) Determine rise time, peak time and peak overshoot of the system **(iv)** Calculate steady state error due to unit step. **(13)**	**BTL3**	Apply
10.	i) Sketch the root locus for a unity feedback control system has an open-loop transfer function $G(s)=\frac{K(s+9)}{s(s^2+4s+11)}$. **(8)**	**BTL 1**	Remember
	ii)List the rules to construct root locus of a system. **(5)**	**BTL 1**	Remember
11.	Sketch the root locus of the system whose open loop Transfer Function is given by $G(s)=\frac{K}{s(s+2)(s+4)}$. Find the value of K so that damping ratio of the system is 0.5. **(13)**	**BTL 1**	Remember
12.	i)Explain briefly the PI controller action with block diagram and obtain its transfer function model. List out its advantages and disadvantages. **(7)**	**BTL 4**	Analyze
	ii)Examine the effect of adding PD and PID in feedback control systems. **(6)**	**BTL 4**	Analyze
13.	Calculate the static error coefficients for a system whose transfer function is $G(s)H(s)=\frac{10}{s(1+s)(1+2s)}$. And also Calculate the steady state error for $r(t)=1+t+\frac{t^2}{2}$. **(13)**	**BTL 3**	Apply
	i)Evaluate the dynamic error coefficients of the following	**BTL 5**	Evaluate

14.	system $G(s) = \dfrac{10}{s(1+s)}$. **(8)**		
	ii)Explain about dynamic error coefficients. **(5)**	**BTL 5**	Remember
15.	i)A unity feedback system has the forward transfer function $G(S)=K_1(2S+1)/S(5S+1)(1+S)^2$ when the input r(t)=1+6t, determine the minimum value of K1 so that the steady state error is less than 0.1 **(6)** (ii) Derive the transfer function of P, PI, PID Controller. **(7)**	**BTL 1**	Remember
16.	Demonstrate the Root locus analysis of the following system. $G(S)=K(S+1)/S(S^2+5S+20)$ **(13)**	**BTL 2**	Understand
17.	What is the response c(t) to the unit step input. Assume that ς =0.5.and also calculate rise time, peak time, Maximum overshoot and settling time. **(13)** 	**BTL 4**	Analyze

PART – C

1.	**(i)** For servomechanisms, with open loop transfer function given below explain what type of input signal give rise to a steady state error and calculate their values. $G(s) = \dfrac{20(s+2)}{s(s+1)(s+3)}$. **(4)** $G(s) = \dfrac{1}{(s+2)(s+3)}$. **(4)**	**BTL 5**	Evaluate
	(ii) Measurements conducted on a Servomechanism show the system response to be c(t)=1+0.2 ê-60t -1.2 ê –10t when subjected to a unit step. Give the expression for closed loop transfer function. **(7)**	**BTL 5**	Evaluate
2.	A unity feedback control system has the open loop transfer function $G(s) = \dfrac{K}{(s+A)(s+2)}$.Evaluate the values of K and A so that the damping ratio is 0.707 and the peak time for unit step	**BTL 5**	Evaluate

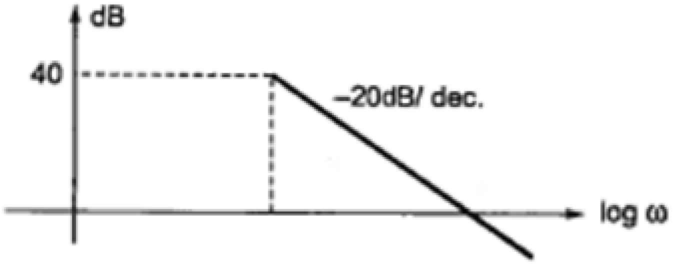
	response is 1.8 sec. **(15)**		
3.	The open loop transfer function of a unity feedback system is given by G(s) = K/s(sT+1) where K and T are positive constant. By what factor the amplifier gain K be reduced, so that the peak overshoot of unit step response of the system is reduced from 75% to 25%. **(15)**	**BTL 6**	Create
4.	Sketch the root locus of the system whose forward transfer function is $G(s)=\frac{K(s+1)}{s(s^2+5s+20)}$. **(15)**	**BTL 6**	Create
5.	(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 5**	Evaluate

UNIT III - FREQUENCY RESPONSE

Frequency response: – Bode plot – Polar plot, Nichols Chart– Determination of closed loop response from open loop response - Correlation between frequency domain and time domain

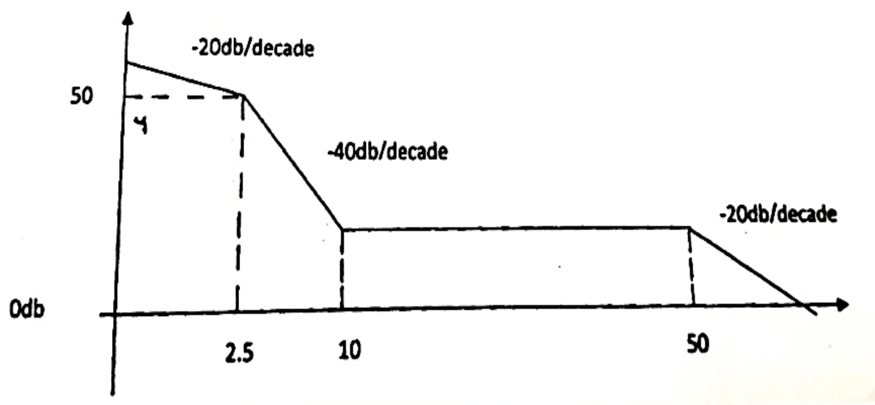
PART – A

Q.No	Questions	BT Level	Competence
1.	A second order system has peak over shoot = 50% and period of oscillations 0.2 seconds. Find the resonant frequency?	**BTL 1**	Remember
2.	What does, a gain margin close to unity or phase margin close to zero indicate?	**BTL 4**	Analyze
3.	What are the effects and limitations of phase-lag control?	**BTL 4**	Analyze
4.	Draw the polar plot of $G(s)=\frac{1}{1+sT}$.	**BTL 3**	Apply
5.	Define phase margin and gain margin.	**BTL 1**	Remember
6.	Analyze the corner frequency of $G(s)=\frac{10}{s(1+0.5s)}$.	**BTL 4**	Analyze
7.	From the magnitude plot, find transfer function and steady state error	**BTL 2**	Understand

	corresponding to step input.  		
8.	Draw the approximate polar plot for a Type 0 second order system.	**BTL 3**	Apply
9.	Define the terms: resonant peak and resonant frequency.	**BTL 1**	Remember
10.	What is meant by cut-off frequency?	**BTL 1**	Remember
11.	Summarize frequency domain specifications.	**BTL 2**	Understand
12.	What are the advantages of frequency domain analysis?	**BTL 1**	Remember
13.	Discuss the correlation between phase margin and Damping factor.	**BTL 2**	Understand
14.	Draw the bode plot of $G(s) = \frac{K}{S^n}$.	**BTL 3**	Apply
15.	Estimate the bode plot of $G(s) = \frac{1}{1+sT}$.	**BTL 6**	Create
16.	Define gain crossover frequency and phase cross over frequency.	**BTL 1**	Remember
17.	If the Bode plot crosses 180 degree line, either at very low frequencies or very high frequencies in the selected frequency range, what is the inference regarding the relationship between open loop gain and stability?	**BTL 2**	Understand
18.	Discuss how you will get closed loop frequency response from open loop response.	**BTL 2**	Understand
19.	The damping ratio and natural frequency of oscillations of a second order system is 0.3 and 3 rad/sec respectively. Calculate resonant frequency and resonant peak.	**BTL 5**	Evaluate
20.	Show the shape of polar plot for the transfer function $K/ s (1+sT_1)(1+sT_2)$	**BTL 3**	Apply
21.	Obtain the Phase angle expression of the given transfer function $GH(s) = \frac{10}{s(1+0.4s)(1+0.01s)}$.	**BTL 5**	Evaluate
22.	Differentiate non-minimum phase and minimum phase systems.	**BTL 4**	Analyze
23.	Explain the uses of Nichol's Chart.	**BTL 5**	Evaluate
24.	Discuss how the closed loop frequency response is determined from open loop frequency response using Nichols chart?	**BTL 6**	Create

PART - B			
1.	Describe the use of Nichol's chart to obtain closed loop frequency response from open loop frequency response of a unity feedback system. Explain how the gain adjustment is carried out on this chart. **(13)**	**BTL 4**	Analyze
2.	Construct bode plot for the system whose open loop transfer function is given below and evaluate (i) Gain margin (ii) Phase margin and (iii) closed loop stability **(13)** $$G(s)=\frac{100}{s(s+1)(s+2)}.$$	**BTL 5**	Evaluate
3.	Plot the bode diagram for the given transfer function and estimate the gain and phase cross over frequencies. **(13)** $GH(s)=\frac{10}{s(1+0.4s)(1+0.1s)}.$	**BTL 2**	Understand
4.	Draw the polar plot of the unity feedback system whose open loop transfer function is given by $G(s)=\frac{1}{s(1+s)(1+2s)}$. Determine the phase and gain margin. **(13)**	**BTL 3**	Apply
5.	Draw the bode plot of the following system and estimate gain cross over frequency. **(13)** $$GH(s)=\frac{10}{s(0.1s+1)(0.01s+1)}.$$	**BTL 2**	Understand
6.	Using polar plot, calculate gain cross over frequency phase cross over frequency, gain margin and phase margin of feedback system with open loop transfer function **(13)** $$GH(s)=\frac{10}{s(1+0.2s)(1+0.002s)}.$$	**BTL 3**	Apply
7.	**(i)** Describe about the frequency domain specifications of a typical system. **(5)**	**BTL 1**	Remember
	(ii) Describe the correlation between time and frequency domain specifications. **(8)**	**BTL 1**	Remember
8.	Given $G(s)=\frac{Ke^{-0.2s}}{s(s+2)(s+8)}$. Draw the Bode plot and Calculate K for the following two cases: (i) Gain margin equal to 6db and (ii) Phase margin equal to 45°. **(13)**	**BTL 3**	Apply

9.	Sketch the Bode Magnitude plot for the transfer function $G(s)=\frac{Ks^2}{s(1+0.2s)(1+0.02s)}$. Hence find 'K' such that gain cross over frequency is 5 rad/sec. **(13)**	**BTL 4**	Analyze
10.	Describe in detail the procedure about Nichol's chart. **(13)**	**BTL 1**	Remember
11.	**(i)** What is the effect on polar plot when pole is added at origin to the transfer function? Explain. Draw the polar plot of a first order system. **(5)**	**BTL 1**	Remember
	(ii) For the following system, sketch the polar plot. $G(s)=\frac{500}{s(s+6)(s+9)}$. **(8)**	**BTL 1**	Apply
12.	**(i)** Derive the expression for radius and centre of constant M and N circles. **(7)**	**BTL 5**	Evaluate
	(ii) Obtain the relation for resonance peak magnitudes $(M_r)$and resonant frequency (ω_r) in terms of damping factor (δ). **(6)**	**BTL 5**	Evaluate
13.	Draw the Bode plot showing the magnitude in decibels and phase angle in degrees as a function of log frequency for the transfer function. $G(s)=\frac{75(1+0.2s)}{s(s^2+16s+100)}$. From the Bode plot, estimate the gain cross-over frequency. **(13)**	**BTL 2**	Understand
14.	Construct the polar plot and determine the gain margin and phase margin of a unity feedback control system whose open loop transfer function is, $G(s)=\frac{(1+0.2s)(1+0.025s)}{s^3(1+0.005s)(1+0.001s)}$. **(13)**	**BTL 6**	Create
15.	Sketch the bode plot for the following transfer function and determine the system gain K for the gain cross over frequency to be 5 rad/sec. $G(s)=\frac{Ks^2}{(1+0.2s)(1+0.02s)}$. **(13)**	**BTL 1**	Remember
16.	Using Nichols chart, determine the closed loop response and estimate M_r, ω_r and ω_b for a unity feedback system has open loop transfer function $G(s)=\frac{20}{s(s+2)(s+5)}$. **(13)**	**BTL 4**	Analyze
17.	With Mathematical expression define the following Frequency	**BTL 2**	Understand

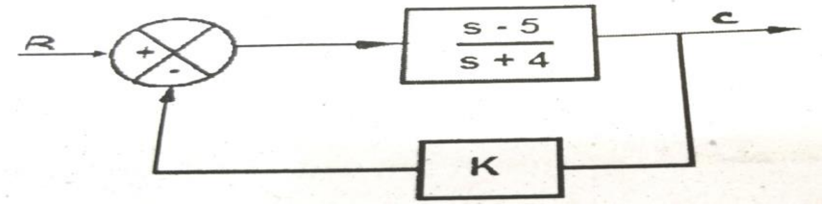
	Domain specifications (i) Gain Margin (ii) Phase Margin (iii) Gain Cross over Frequency (iv) Phase Cross over Frequency (v) Resonant Peak (vi) Resonant Frequency (vii) Bandwidth. **(13)**		
	PART - C		
1.	Formulate the transfer function of the system whose experimental frequency response data is given below. (Error between actual plot and asymptotic plot at corner frequency 10 is -6db). **(15)** 	**BTL 6**	Create
2.	Sketch the polar plot for the following transfer function and evaluate Gain cross over frequency, Phase cross over frequency, Gain margin and Phase margin for $G(s)=\frac{400}{s(s+2)(s+10)}$. **(15)**	**BTL 5**	Evaluate
3.	The open loop transfer function of a unity feedback system is given by $G(s)=\frac{1}{s^2(1+s)(1+2s)}$. Sketch the polar plot and determine the gain margin and phase margin. **(15)**	**BTL 5**	Evaluate
4.	Sketch the Bode plot and hence evaluate Gain cross over frequency, Phase cross over frequency, Gain margin and Phase margin for the function $G(s)=\frac{10(s+3)}{s(s+2)(s^2+4s+100)}$. **(15)**	**BTL 5**	Evaluate
5.	Using Nichols chart plot the closed loop frequency response of a system having open loop transfer function as $G(s)=\frac{10}{s(0.1s+1)(0.05s+1)}$. **(15)**	**BTL 6**	Create

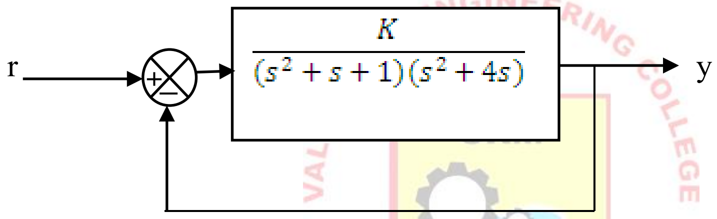
UNIT IV - STABILITY AND COMPENSATOR DESIGN

Characteristics equation – Routh Hurwitz criterion – Nyquist stability criterion- Lag ,lead, lag-lead network, Performance criteria – Effect of Lag, lead and lag-lead compensation on frequency response-Design of Lag, lead and lag- lead compensator using bode plots.

PART - A

Q.No	Questions	BT Level	Competence
1.	What are the two notations of system stability to be satisfied for a linear time-invariant system to be stable?	**BTL 1**	Remember
2.	Why are compensators required in feedback control system? What is compensation?	**BTL 4**	Analyze
3.	Give any two limitations of Routh-stability criterion.	**BTL 2**	Understand
4.	How are the roots of the characteristic equation of a system related to stability?	**BTL 1**	Remember
5.	Examine BIBO stability.	**BTL 3**	Apply
6.	Realise the lead compensator using R and C network components.	**BTL 2**	Understand
7.	State Nyquist stability criterion.	**BTL 1**	Remember
8.	What is characteristic equation?	**BTL 1**	Remember
9.	The transfer function of a phase lead compensator is given by $G(s)=\frac{(1+3Ts)}{(1+Ts)}$. where T>0. What is the maximum phase shift provided by such a compensator?	**BTL 2**	Understand
10.	Evaluate the effects of adding a zero to a system?	**BTL 5**	Evaluate
11.	What conclusion can be provided when there is a row of all zeros in Routh array?	**BTL 2**	Understand
12.	Point out the regions of root locations for stable, unstable and limitedly stable systems.	**BTL 4**	Analyze
13.	Write the necessary and sufficient condition for stability.	**BTL 6**	Create
14.	What is the desired performance criteria specified in compensator design?	**BTL 1**	Remember
15.	For what range of K, the following system shown in Fig is asymptotically stable?	**BTL 3**	Apply

			
16.	A open loop transfer function is given as $G(s)=\dfrac{(s+2)}{(s+1)(s-1)}$. Find the number of encirclements about '-1+j0'?	**BTL 3**	Apply
17.	What are the effects of adding open loop poles and zero on the nature of the root locus and on system?	**BTL 1**	Remember
18.	Point out some properties of Nyquist plot.	**BTL 4**	Analyze
19.	Identify the necessity for lag/lag-Lead compensation.	**BTL 3**	Apply
20.	Design a circuit for lead compensator along with pole zero diagram.	**BTL 6**	Create
21.	Explain the Phase Lag compensator and why is it used?	**BTL 2**	Understand
22.	Draw the polar plot of Lag Lead compensator.	**BTL 4**	Analyze
23.	Compare Lag and Lead compensator	**BTL 5**	Evaluate
24.	Draw the circuit of lead compensator and draw its pole-zero diagram	**BTL 5**	Evaluate
	PART - B		
1.	By use of Nyquist stability criterion, discuss whether the closed loop system having the following open loop transfer function is stable or not. If not how many closed loop poles lie in the right half of s-plane? **(13)** $$G(s)H(s)=\frac{s+2}{(s+1)(s-1)}.$$	**BTL 2**	Understand
2.	The open loop transfer function of a unity feedback system is given by $G(s)H(s)=\dfrac{K}{(s+2)(s+4)(s^2+6s+25)}$. By applying the Routh criterion, find the range of values of k for which the closed loop system is stable. Calculate the values of k which will cause sustained oscillations in the closed loop system. What are the corresponding oscillation frequencies? **(13)**	**BTL 3**	Apply
3.	(i) Examine the stability of the system whose characteristic equation is given by $s^5+4s^4+8s^3+8s^2+7s+4=0$. Using Routh Hurwitz criterion. **(6)**	**BTL 2**	Understand

	(ii) Assume any four different pole locations for a system, sketch the response and comment on stability of each case **(7)**		
4.	Write the procedure for lag lead compensator using bode plot in detail. **(13)**	**BTL 1**	Remember
5.	Sketch the Nyquist plot for the System whose open loop transfer function is $G(s)=\frac{K}{s(s+2)(s+10)}$. Determine the range of K for which the closed loop System is Stable. **(13)**	**BTL 3**	Apply
6.	The open loop transfer function of the uncompensated system is $G(s)=\frac{K}{s(s+1)}$. Design a lead compensator for the system so that the static velocity error constant K_v is 10/sec, the phase margin is at least 35^0. **(13)**	**BTL 5**	Evaluate
7.	Consider the closed loop system shown in figure point out the range of K for the system which is stable. **(13)** 	**BTL 4**	Analyze
8.	From the first principles explain how you obtain the stability of a linear system using Nyquist criterion. **(13)**	**BTL 4**	Analyze
9.	Consider the unity feedback system whose open loop transfer function is $G(s)=\frac{K}{s(0.1s+10)(0.2s+1)}$. Design a suitable compensator to meet the following specifications. **(i)** velocity error constant, $K_v = 30$ **(ii)** phase margin $\phi_M \geq 50°$. **(iii)** Band width $\omega_1 = 12$ rad/sec. **(13)**	**BTL 6**	Create
10.	For each of the characteristics equation of feedback control system given, determine the range of K for stability. Examine the value of K so that the system is marginally stable and the frequency of sustained oscillations. **(13)** **(i)** $s^4+25s^3+15s^2+20s+K=0$. **(ii)** $s^3+3Ks^2+(K+2)s+4=0$.	**BTL 1**	Remember

11.	**(i)** 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)**	**BTL 3**	Apply
	(ii) State Routh Stability criterion. **(3)**	**BTL 2**	Understand
12.	**(i)** Sketch the Bode plot of a typical lag-lead compensator and express its transfer function. **(3)**	**BTL 2**	Understand
	(ii) The open loop transfer function of the uncompensated system is $G(s)=\dfrac{5}{s(s+2)}$. Design a suitable lag compensator for the system so that the static velocity error constant K_v is 20/sec, the phase margin is at least 55^0 and the gain margin is at least 12 db. **(10)**	**BTL 2**	Understand
13.	Draw the circuit of lag-lead compensator and derive its transfer function. What are its effects? **(13)**	**BTL 1**	Remember
14.	By use of the Nyquist criterion, discuss whether closed-loop systems having the following open-loop transfer function is stable or not. If not, how many closed loop poles lies in the right half of s-plane? **(13)** $G(s)H(s)=\dfrac{10}{s(s+1)(2s+1)}$.	**BTL 4**	Analyze
15.	Explain the effect of Lag, lead and lag-lead compensation on frequency response in detail. **(13)**	**BTL 5**	Evaluate
16.	Describe the procedure for a lag compensator. **(13)**	**BTL 1**	Remember
17.	(i) Discuss the limitations and effects of phase lead compensator. **(07)** (ii) Discuss the condition in which phase lead network cannot be used successfully. **(06)**	**BTL 6**	Create

PART - C

1.	Sketch the Nyquist plot for a system and find the stability, whose open loop transfer function is given by $G(s)=\dfrac{10}{s^2(s+2)}$. **(15)**	**BTL 5**	Evaluate
2.	The open loop transfer function of the uncompensated system is $G(s)=\dfrac{K}{s(s+2)}$. Design a lag compensator for the system so that	**BTL 5**	Evaluate

	the static velocity error constant K_v is 10 sec^{-1}, the phase margin ≥ 60^0. **(15)**		
3.	**(i)** Using Routh criterion, determine the stability of a system representing the characteristic equation $s^4 + 8s^3 + 18s^2 + 16s + 5 = 0$. Comment on location of the roots of the characteristics equation. **(9)** **(ii)** Write down the procedure for designing Lag compensator using Bode plot. **(6)**	**BTL 6**	Create
4.	For the given system, $G(s) = \dfrac{K}{s(s+1)(s+2)}$, design a suitable lag-lead compensator to give, velocity error constant=10 sec^{-1}, phase margin=50^0, gain margin ≥ 10 Db **(15)**	**BTL 3**	Apply
5.	Design a suitable lead compensator foe a system with unity feedback and having open loop transfer function $G(s) = \dfrac{K}{s(s+1)(s+4)}$ to meet the specifications as damping ratio = 0.5 and undamped natural frequency=2 rad/sec. **(15)**	**BTL 6**	Create

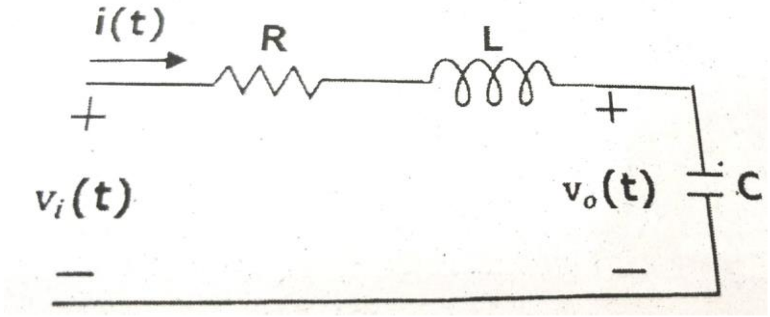
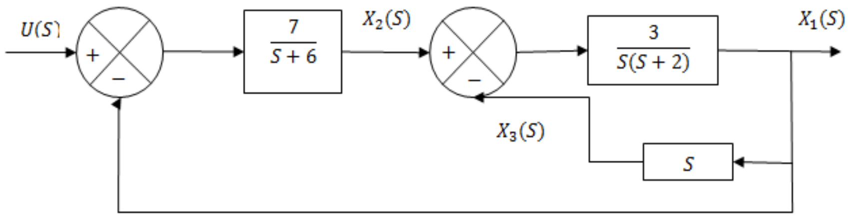
UNIT V - STATE VARIABLE ANALYSIS

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.

PART - A

Q.No	Questions	BT Level	Competence
1.	Sketch the block diagram representation of a state model.	**BTL 3**	Apply
2.	Obtain the state space model for the given differential equation $\dfrac{d^3Y}{dt^2} + 6\dfrac{d^2Y}{dt^2} + 11\dfrac{dY}{dt} + 6Y = U(t)$. Evaluate the transfer function model.	**BTL 1**	Remember
3.	Consider a system whose transfer function is given by $\dfrac{Y(s)}{U(s)} = \dfrac{10}{s^3 + 6s^2 + 5s + 10}$. Solve and obtain a state model for this system.	**BTL 1**	Remember

4.	Discuss state and state variable.	**BTL 2**	Understand
5.	When do you say that a system is completely state controllable?	**BTL 1**	Remember
6.	List the advantages of state space analysis.	**BTL 1**	Remember
7.	Give the condition for controllability by Kalman's method.	**BTL 2**	Understand
8.	State the condition for observability by Gilbert's method.	**BTL 3**	Apply
9.	Write the homogeneous and non-homogeneous state equation.	**BTL 1**	Remember
10.	Analyze the concept of controllability.	**BTL 4**	Analyze
11.	What are the advantages of state variable techniques?	**BTL 5**	Evaluate
12.	How is pole placement done by state feedback in a sampled data system?	**BTL 3**	Apply
13.	Formulate the necessary condition to be satisfied for designing state feedback.	**BTL 5**	Evaluate
14.	Point out the limitations of physical system modelled by transfer function approach.	**BTL 4**	Analyze
15.	State the mechanism in control engineering which implies an ability to measure the state by taking measurements at output.	**BTL 1**	Remember
16.	Give the need of observability test.	**BTL 2**	Understand
17.	Define the following terms such as (i) State (ii) State Variable (iii) State Vector (iv) State Space Model.	**BTL 3**	Apply
18.	Write the properties of state transition matrix.	**BTL 6**	Create
19.	Give the types of systems that can be analysed through state space analysis.	**BTL 2**	Understand
20.	Analyze the concept of canonical form of state model.	**BTL 4**	Analyze
21.	Design the state model of a linear time invariant system.	**BTL 6**	Create
22.	Evaluate the effect of state feedback.	**BTL 5**	Evaluate
23.	Illustrate Cayley-Hamilton theorem.	**BTL 2**	Understand
24.	List the applications of state space model.	**BTL 4**	Analyze
	PART - B		
1.	Consider a linear system described by the transfer function. $\frac{Y(s)}{U(s)} = \frac{5}{s(s+2)(s+3)}$. Design a feedback controller with a state feedback so that the closed loop poles are placed at -1, -2±2j. **(13)**	**BTL 5**	Evaluate
2.	Explain with neat diagram, the working of DC and AC tacho generators. **(13)**	**BTL 2**	Understand
3.	Consider the following RLC series circuit shown in Fig and obtain	**BTL 2**	Understand

	its state model. **(13)**  		
4.	Obtain the state space representation of Armature controlled dc motor and Field controlled dc motor. **(13)**	**BTL 4**	Analyze
5.	Examine the controllability and observability of a system having following coefficient matrices. **(13)** $A=\begin{bmatrix}0 & 1 & 0\\0 & 0 & 1\\-6 & -11 & -6\end{bmatrix}; B=\begin{bmatrix}1\\0\\1\end{bmatrix}; C^T=\begin{bmatrix}10\\5\\1\end{bmatrix}$	**BTL 1**	Remember
6.	List the state equation for the system shown below in which x_1, x_2 and x_3 constitute the state vectors. Examine whether the system is completely controllable and observable. **(13)**  	**BTL 3**	Apply
7.	Consider a control system with state model $\begin{bmatrix}\dot{x}_1\\\dot{x}_2\end{bmatrix}=\begin{bmatrix}0 & 1\\-2 & -3\end{bmatrix}\begin{bmatrix}x_1\\x_2\end{bmatrix}+\begin{bmatrix}0\\2\end{bmatrix}u;$ $\begin{bmatrix}x_1(0)\\x2(0)\end{bmatrix}=\begin{bmatrix}0\\1\end{bmatrix};$ Compute the state transition matrix. **(13)**	**BTL 3**	Apply
8.	Consider the following plant of the state space representation: Examine the controllability and observability of a state space formed by the system. **(13)** $A=\begin{bmatrix}0 & 1\\-2 & -3\end{bmatrix}; B=\begin{bmatrix}-2\\2\end{bmatrix}; C=\begin{bmatrix}-2 & 0\end{bmatrix}$	**BTL 1**	Remember
9.	Examine the controllability and observability of the system with state equation. **(13)**	**BTL 1**	Remember

	$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix}=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ 0 & -2 & -3\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}+\begin{bmatrix}0\\ 0\\ 1\end{bmatrix}u;$ $y=\begin{bmatrix}3 & 4 & 1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}$		
10.	A system is characterized by the transfer function $$\frac{Y(s)}{U(s)}=\frac{3}{(s^3+5s^2+11s+6)}$$ Express whether or not the system is completely controllable and observable also identify the first state as output. **(13)**	**BTL 2**	Understand
11.	Obtain the complete solution of non-homogeneous state equation using time domain method**.** **(13)**	**BTL 5**	Evaluate
12.	(i) Find the state and output equation for $$G(s)=\frac{1}{(s^3+4s^2+3s+3)}$$ **(7)** (ii) Obtain state space representation for system $y''+6y'+2y=0$**(6)**	**BTL 1**	Remember
13.	Express the canonical state model of the system, whose transfer function is $T(s)=\frac{2(s+5)}{(s+2)(s+3)(s+4)}$ **(13)**	**BTL 2**	Understand
14.	Examine the controllability and observability of the following state space system. **(13)** $\dot{x}_1=x_2+u_2$ $\dot{x}_2=x_3$ $\dot{x}_3=-2x_2-3x_3+u_1+u_2$	**BTL 5**	Evaluate
15.	**(i)** Derive the transfer function model for the following state space system. **(7)** $A=\begin{bmatrix}0 & 1\\ -6 & -5\end{bmatrix}; B=\begin{bmatrix}1\\ 0\end{bmatrix}; C=\begin{bmatrix}1 & 0\end{bmatrix}; D=\begin{bmatrix}0\end{bmatrix}$	**BTL 4**	Analyze
	(ii) Find the state transition matrix for the state model whose	**BTL 4**	Analyze

	system matrix A is given by $A=\begin{bmatrix}1 & 1\\ 0 & 1\end{bmatrix}$ **(6)**		
16.	Obtain the state space representation of observable canonical form $\frac{Y(s)}{U(s)}=\frac{s+4}{(s^2+5s+2)}$ **(7)**	**BTL 3**	Apply
	Explain the concept of controllability and observability by Kalman's and Gilbert's method. **(6)**	**BTL 4**	Analyze
17.	Formulate the expression for the state space model for the continuous system and also draw the state diagram for it. **(13)**	**BTL 6**	Create
PART - C			
1.	Test the controllability and observability of the system with state equation. **(15)** $\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix}=\begin{bmatrix}-1 & 0 & 0\\ 1 & -2 & 0\\ 2 & 1 & -3\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}+\begin{bmatrix}10\\ 1\\ 0\end{bmatrix}u;$ $y=\begin{bmatrix}1 & 0 & 0\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}$	**BTL 5**	Evaluate
2.	**(i)** Given that $A_1=\begin{bmatrix}\sigma & 0\\ 0 & \sigma\end{bmatrix}; A_2=\begin{bmatrix}0 & \omega\\ -\omega & 0\end{bmatrix}; A_2=\begin{bmatrix}\sigma & \omega\\ -\omega & \sigma\end{bmatrix}$; Compute state transition matrix. **(8)** **(ii)** Explain the concepts of controllability and observability. **(7)**	**BTL 5**	Evaluate
3.	**(i)**Determine whether the system described by the following state model is completely controllable and observable. **(8)** $\dot{x}(t)=\begin{bmatrix}0 & 0 & 1\\ -2 & -3 & 0\\ 0 & 2 & -3\end{bmatrix}\begin{bmatrix}x_1(t)\\ x_2(t)\\ x_3(t)\end{bmatrix}+\begin{bmatrix}0\\ 2\\ 0\end{bmatrix}u(t);$ $y(t)=\begin{bmatrix}1 & 0 & 0\end{bmatrix}\begin{bmatrix}x_1(t)\\ x_2(t)\\ x_3(t)\end{bmatrix}$ **(ii)** What are state variables? Explain the state space formulation	**BTL 6**	Create

	with its equation. **(7)**		
4.	Determine the state variable representation of the system whose transfer function is given as $\frac{Y(s)}{U(s)} = \frac{2s^2+8s+7}{(s+2)^2(s+1)}$. **(15)**	**BTL 6**	Create
5.	Consider a matrix $A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}; A^2 = \begin{bmatrix} -2 & -3 \\ 6 & 7 \end{bmatrix}$ .Compute e^{AT} by two methods. **(15)**	**BTL 5**	Evaluate

COURSE OUTCOMES:

COE1: Ability to develop various representations of system based on the knowledge of Mathematics, Science and Engineering fundamentals.

COE2: Ability to do time domain and frequency domain analysis of various models of linear system.

COE3: Ability to interpret characteristics of the system to develop mathematical model.

COE4: Ability to understand and design appropriate compensator for the given specifications.

COE5: Ability to design State variable representation of physical systems.