INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad-500043

ELECTRONICS AND COMMUNICATION ENGINEERING

TUTORIAL QUESTION BANK

Course Title	CONTROL SYSTEMS				
Course Code	AEEB16				
Programme	B.Tech				
Semester	IV				
Course Type	CORE				
Regulation	IARE - R18				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	-	-
Chief Coordinator	Dr. M Pala Prasad Reddy, Associate Professor				
Course Faculty	Ms. S Swathi, Assistant Professor Ms. L Babitha, Assistant Professor				

COURSE OBJECTIVES:
The course should enable the students to:

I	Organize modeling and analysis of electrical and mechanical systems.
II	Analyse control systems by block diagrams and signal flow graph technique.
III	Demonstrate the analytical and graphical techniques to study the stability.
IV	Illustrate the frequency domain and state space analysis.

COURSE OUTCOMES (COs):

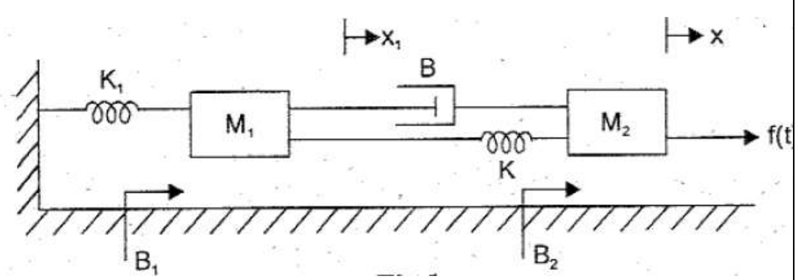
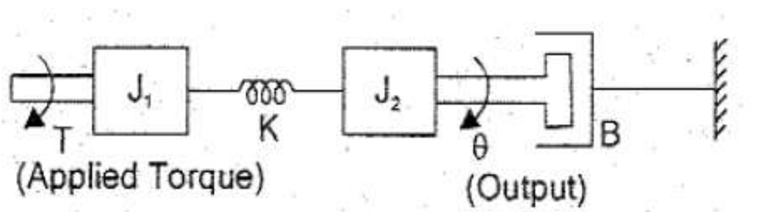
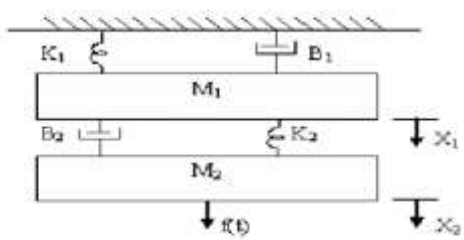
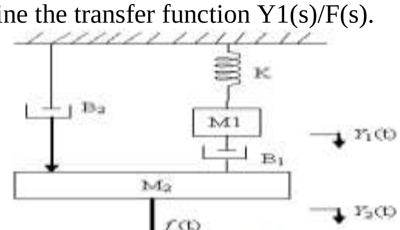
CO1	Classify the types and configurations of control systems and describe the mathematical models of dynamic systems
CO2	Apply various techniques to obtain transfer functions and examine the time response of control systems using standard test signals
CO3	Analyze the system response and stability in time domain

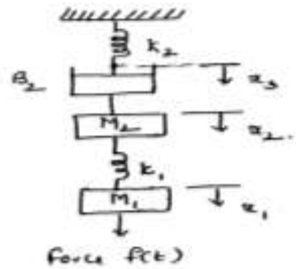
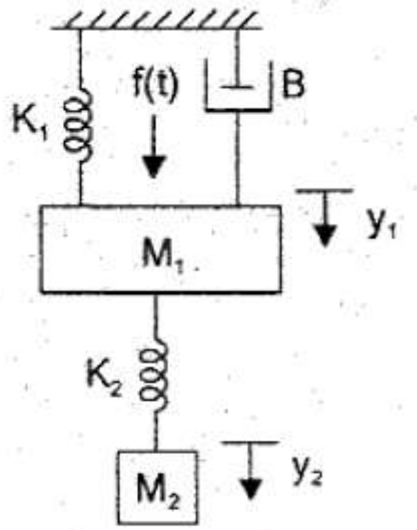
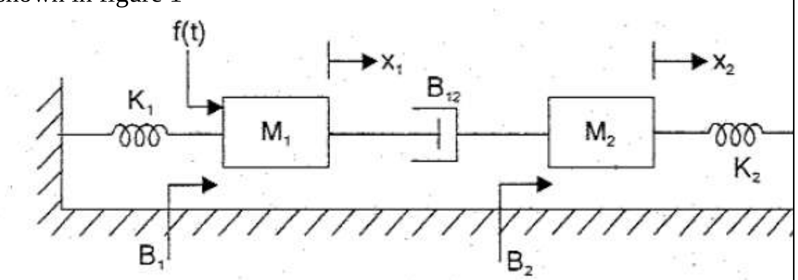
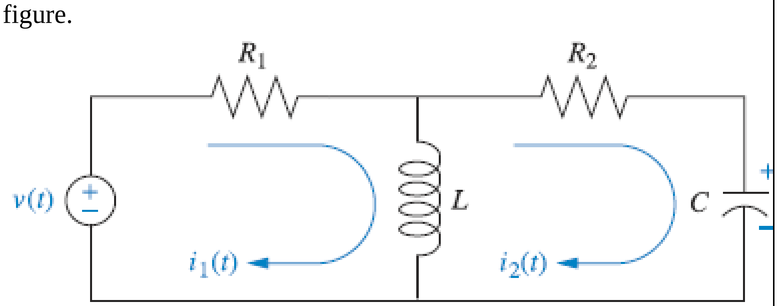
CO4	Examine the characteristics and stability of control systems in frequency domain.
CO5	Obtain the models of control systems in state space form and design compensators to meet the desired specifications.

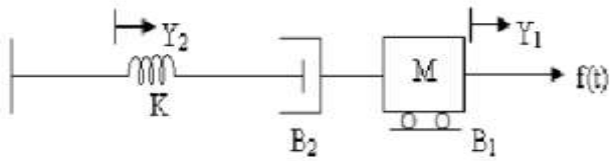
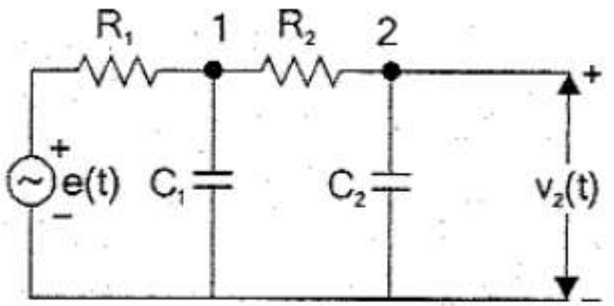
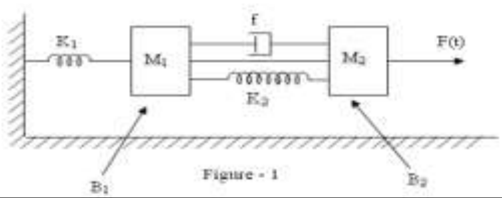
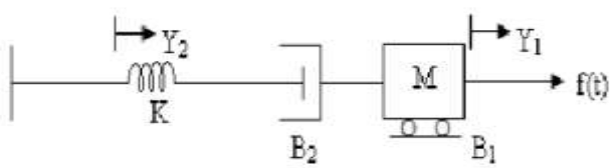
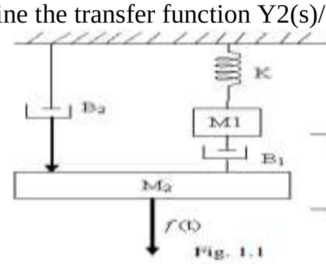
COURSE LEARNING OUTCOMES:
Students, who complete the course, will have demonstrated the ability to do the following:

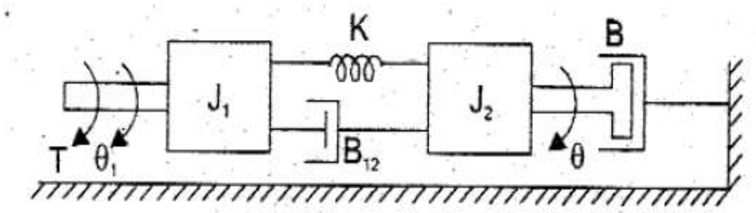
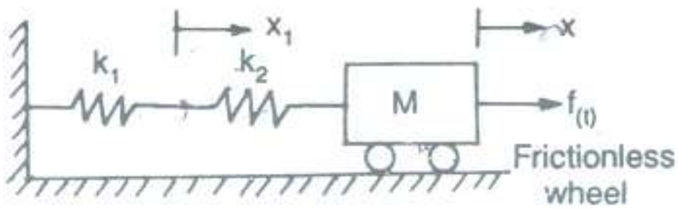
S. No	Description
AEEB16.01	Differentiate between open loop, closed loop system and their importance in real time applications.
AEEB16.02	Predict the transfer function of translational and rotational mechanical, electrical system using differential equation method.
AEEB16.03	Analyze the analogy between translation and rotational mechanical systems.
AEEB16.04	Apply the block diagram and signal flow graph technique to determine transfer function of an control systems.
AEEB16.05	Demonstrate the response of first order and second order systems with various standard test signals.
AEEB16.06	Estimate the steady state error and its effect on the performance of control systems and gives the importance of PID controllers.
AEEB16.07	Summarize the procedure of routh – hurwirtz criteria to steady the stability of electrical systems.
AEEB16.08	List the steps required to draw root – locus of any control system and their by predict the stability.
AEEB16.09	Explain the effect of adding zeros and poles to the transfer function of control system for improving stability.
AEEB16.10	Discuss the method of bode plot and polar plot to calculate gain margin and phase margin of control system.
AEEB16.11	Describe the characteristics of control system and its stability by drawing nyquist plot.
AEEB16.12	Compare the behaviour of control system in terms of time domain and frequency domain response.
AEEB16.13	Define the state model of control system using its block diagram and give the role of diagonalization in state space analysis.
AEEB16.14	Formulate state transmission matrix and explain the concept of controllability and observability.
AEEB16.15	Design lag, lead, lead – lag compensation to improve stability of control system/
AEEB16.16	Apply the concept of electromagnetic and electrostatic fields to solve real time world applications.
AEEB16.17	Explore the knowledge and skills of employability to succeed in national and international level competitive examinations.

MODULE – I				
INTRODUCTION AND MODELING OF PHYSICAL SYSTEMS				
Part - A(Short Answer Questions)				
S No	**QUESTION**	**Blooms Taxonomy level**	**Course Outcomes**	**Course Learning Outcomes**
1	What is control system?	Remember	CO1	AEEB16.01
2	Define open loop control system?	Understand	CO1	AEEB16.01
3	Define closed loop control system?	Understand	CO1	AEEB16.01
4	Define transfer function?	Remember	CO1	AEEB16.01
5	Write examples for open loop and closed loop control systems?	Understand	CO1	AEEB16.01
6	Compare open loop and closed loop control systems?	Understand	CO1	AEEB16.01
7	What are the basic elements used for modelling mechanical rotational system?	Understand	CO1	AEEB16.02
8	Write the force balance equation of ideal mass element?	Understand	CO1	AEEB16.02
9	Write the force balance equation of ideal dashpot element?	Understand	CO1	AEEB16.02
10	Write the force balance equation of ideal spring element?	Remember	CO1	AEEB16.02
11	Write the analogous electrical elements in force voltage analogy for the elements of mechanical translational system?	Remember	CO1	AEEB16.03
12	Write the analogous electrical elements in force current analogy for the elements of mechanical translational system?	Remember	CO1	AEEB16.03
13	What are the basic elements used for modelling mechanical translational system?	Remember	CO1	AEEB16.02
14	Write the torque balance equation of ideal rotational mass element?	Remember	CO1	AEEB16.02
15	Write the torque balance equation of ideal dash-pot element?	Understand	CO1	AEEB16.02
Part - B (Long Answer Questions)				
1	Explain open loop and closed loop control systems with suitable examples.	Understand	CO1	AEEB16.01
3	Explain the difference between open loop and closed loop systems.	Remember	CO1	AEEB16.01
4	Illustrate any three applications of feedback control systems.	Remember	CO1	AEEB16.01
5	Explain the classification of control systems.	Remember	CO1	AEEB16.01
6	Describe the effect of feedback on Gain, Stability, Noise and Sensitivity of a closed loop control system.	Remember	CO1	AEEB16.01
7	Explain the open loop and closed loop configurations of a temperature control system.	Understand	CO1	AEEB16.01
8	A single input – single output system with zero initial conditions is described by the differential equation $\frac{d^4x}{dt^4}+2\frac{d^3x}{dt^3}+3\frac{d^2x}{dt^2}+1.5\frac{dx}{dt}+0.5x=y+0.5\frac{dy}{dt}+0.2\frac{d^2y}{dt^2}$ Determine the transfer function $X(s)/Y(s)$.	Understand	CO1	AEEB16.01
9	The transfer function of a system is given by $\frac{X(s)}{Y(s)}=G(s)=\frac{s^3+3s^2+2s+1}{s^5+4s^4+3s^3+2s^2+s+1}$ Determine the differential governing it.	Remember	CO1	AEEB16.02
10	Determine the transfer function of RLC series circuit if the voltage across the capacitor is a output variable and input is voltage source v(s).	Understand	CO1	AEEB16.02
11	Determine the transfer function of RLC parallel circuit if the voltage across the capacitor is a output variable and input is current source i(s).	Understand	CO1	AEEB16.02

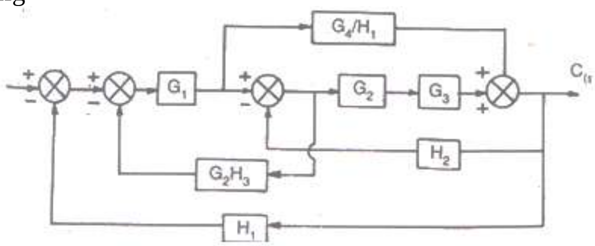
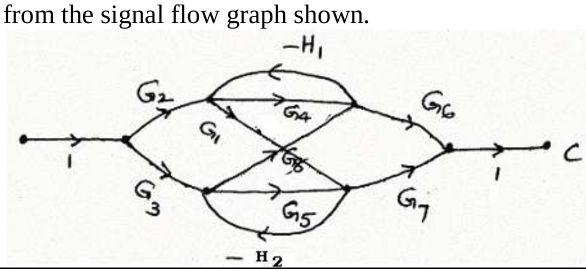
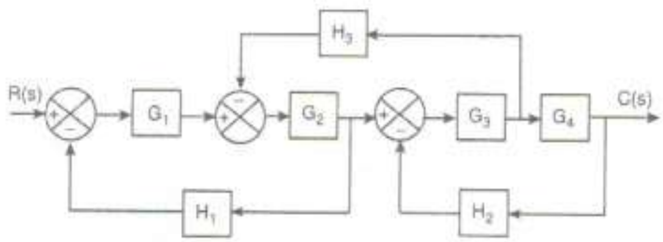
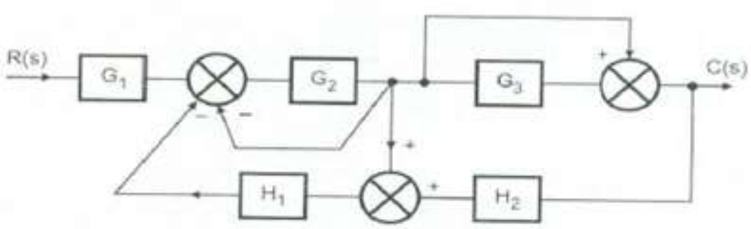
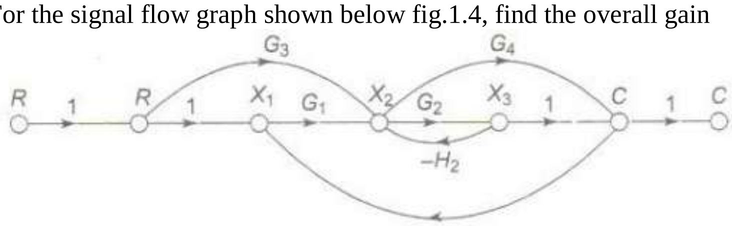
12	Write the force balance equations of idealized elements of mechanical translational systems.	Remember	CO1	AEEB16.02
13	Write the torque balance equations of idealized elements of mechanical rotational systems.	Remember	CO1	AEEB16.02
14	Write the analogous quantities in force-voltage analogy and force – current analogy	Remember	CO1	AEEB16.02
15	Explain the significance of a transfer function stating its advantages, features and limitations.	Remember	CO1	AEEB16.03
Part - C (Problem Solving and Critical Thinking Questions)				
1	Write the differential equations governing the Mechanical system shown in fig. and determine the transfer function? 	Remember	CO1	AEEB16.02
2	Write the differential equations governing the Mechanical rotational system shown in fig. find the transfer function? 	Understand	CO1	AEEB16.02
3	Obtain the transfer function X1(s)/F(s) for the mechanical system as shown in figure. 	Understand	CO1	AEEB16.02
4	Write the differential equations governing the mechanical system shown below and determine the transfer function Y1(s)/F(s).  Fig. 1.1	Remember	CO1	AEEB16.02

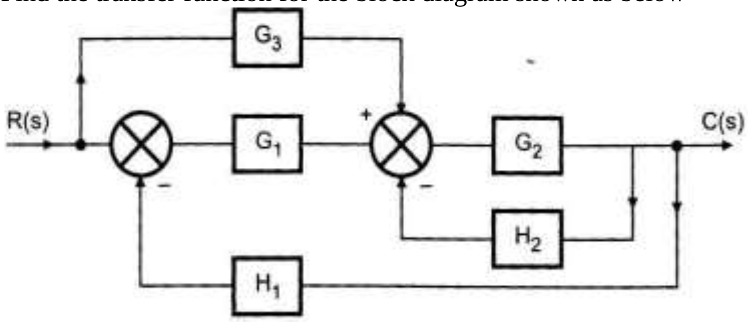
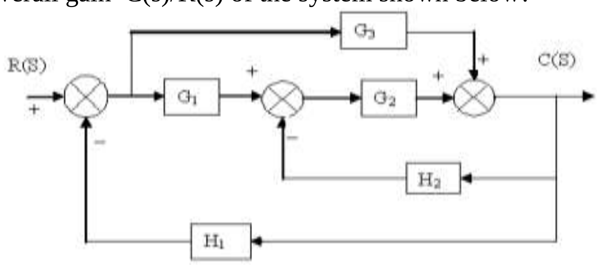
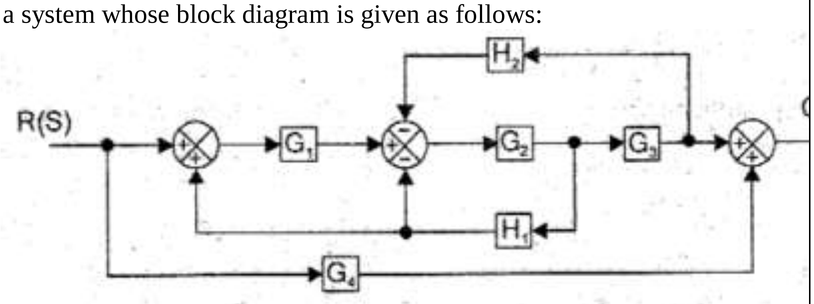
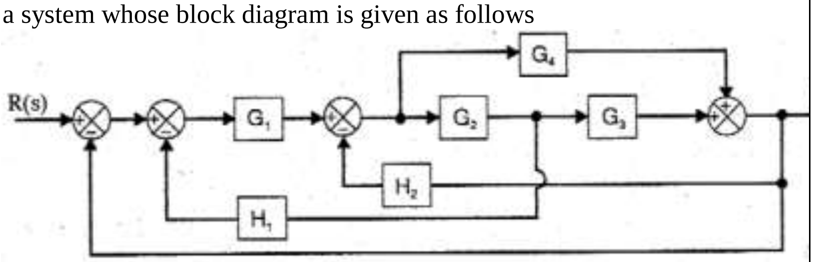
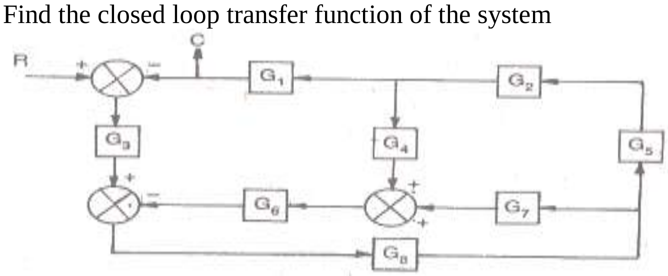
5	Draw the electrical analogous circuit of the mechanical system shown below. 	Understand	CO1	AEEB16.03
6	Determine the transfer function Y2(S)/F(S) of the system shown in fig. 	Understand	CO1	AEEB16.02
7	Obtain the transfer function $\frac{X_1(s)}{F(s)}, \frac{X_2(s)}{F(s)}$ of the mechanical system shown in figure 1 	Understand	CO1	AEEB16.02
8	Find the transfer function $I_2(s)/V(s)$ of the electrical network shown in figure. 	Remember	CO1	AEEB16.02

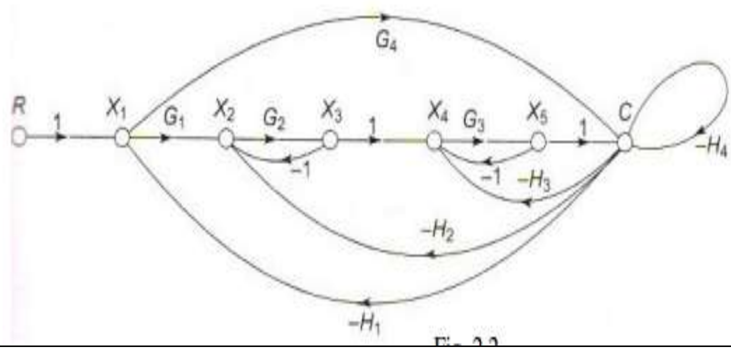
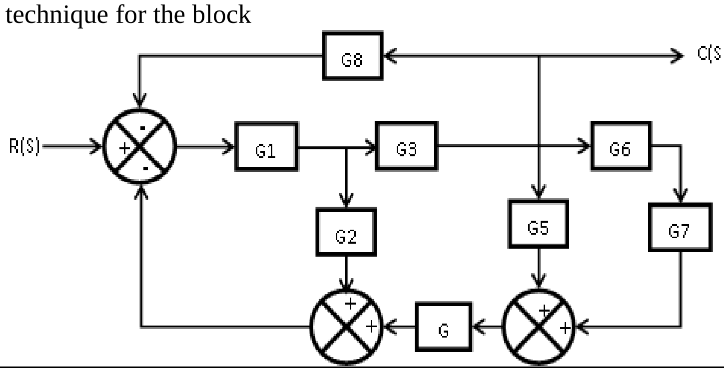
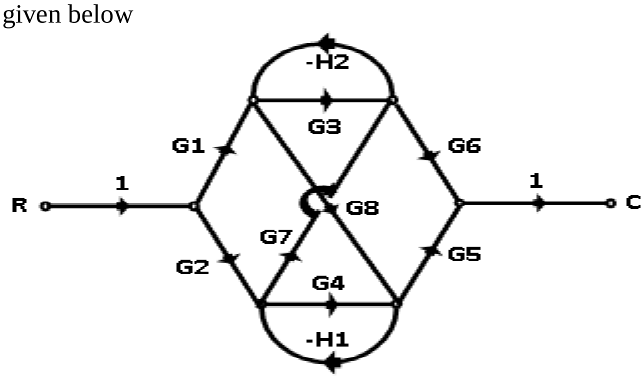
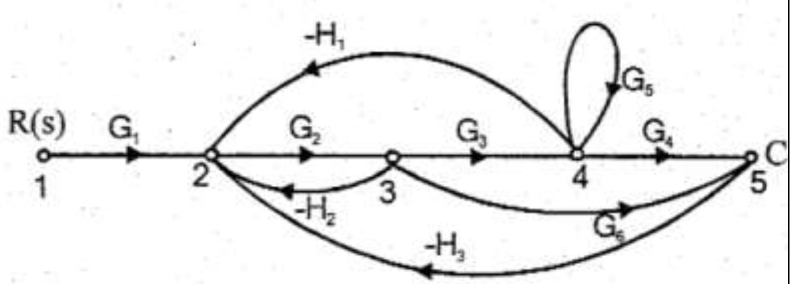
9	For the mechanical system shown in Figure, determine the transfer function $\frac{Y_1(s)}{F(s)}$ 	Remember	CO1	AEEB16.02
10	For the given electrical circuit find transfer function v2(s)/e(s) 	Remember	CO1	AEEB16.02
11	Obtain the transfer function Y2(s)/F(s) of the mechanical system shown in figure 1 	Remember	CO1	AEEB16.02
12	For the mechanical system shown in Figure 3, determine the transfer function Y2(s)/F(s) 	Understand	CO1	AEEB16.02
13	Write the differential equations governing the mechanical system shown below and determine the transfer function Y2(s)/F(s). 	Understand	CO1	AEEB16.02

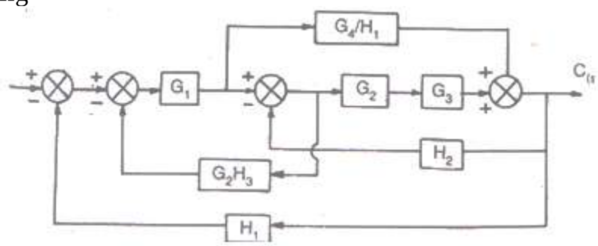
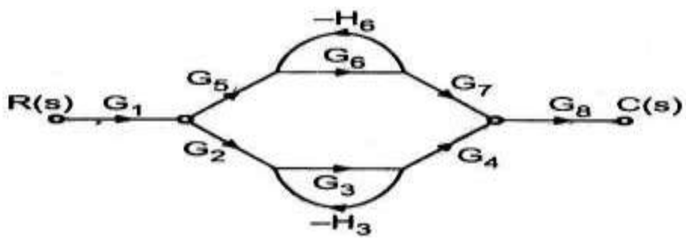
14	Find the transfer function $\frac{\theta(s)}{T(s)}$ for the system shown in figure. 	Remember	CO1	AEEB16.02
15	Obtain transfer function of the system shown in fig. 	Understand	CO1	AEEB16.02
MODULE - II				
BLOCK DIAGRAM REDUCTION AND TIME RESPONSE ANALYSIS				
Part – A (Short Answer Questions)				
1	What is block diagram?	Remember	CO2	AEEB16.04
2	What is the basis for framing the rules of block diagram reduction technique?	Remember	CO2	AEEB16.04
3	What are the components of block diagram?	Remember	CO2	AEEB16.04
4	What is transmittance?	Remember	CO2	AEEB16.04
5	What is sink and source?	Remember	CO2	AEEB16.04
6	Write Masons Gain formula?	Understand	CO2	AEEB16.04
7	Define non- touching loop?	Remember	CO2	AEEB16.04
8	What is a signal flow graph?	Remember	CO2	AEEB16.04
9	Define forward path?	Understand	CO2	AEEB16.04
10	Write the rule for moving summing point a head of a block?	Understand	CO2	AEEB16.04
11	Define loop?	Understand	CO2	AEEB16.04
12	What is Proportional controller and what are its advantages?	Remember	CO2	AEEB16.06
13	What is the drawback in P-controller?	Understand	CO2	AEEB16.06
14	What is integral control action? What is the advantage and disadvantage in integral controller?	Understand	CO2	AEEB16.06
15	What is PI, PD, PID controller?	Remember	CO2	AEEB16.06
16	Define Damping ratio.	Understand	CO2	AEEB16.05
17	Distinguish between type and order of a system?	Understand	CO2	AEEB16.05
18	Define rise, Delay time	Understand	CO2	AEEB16.05
19	Define Peak time? Write formula?	Remember	CO2	AEEB16.05
20	Give the relation between generalized and static error coefficients?	Remember	CO2	AEEB16.05
21	What are generalized error coefficients?	Remember	CO2	AEEB16.05

22	Define settling time and write formula?	Remember	CO2	AEEB16.05
23	Define Peak overshoot and write formula?	Understand	CO2	AEEB16.05
24	How the system is classified depending on the value of damping?	Understand	CO2	AEEB16.05
25	Find the type and order of the system G(S)=40/s(s+4)(s+5)(s+2)	Remember	CO2	AEEB16.05
26	Find the type and order of the system G(S)=40/s(s+4)(s+5)(s+2)	Understand	CO2	AEEB16.05
Part - B (Long Answer Questions)				
1	Derive the transfer function of a field controlled DC servomotor and develop its block diagram. State the assumptions made if any.	Understand	CO2	AEEB16.04
2	Derive the transfer function of an armature controlled DC servomotor and develop its block diagram	Remember	CO2	AEEB16.04
3	(a) Write short notes on impulse response of a system? (b) How transfer function is related to unit impulse response of a system?	Understand	CO2	AEEB16.04
4	(a) Explain the differences between field controlled and armature controlled DC servomotor? (b) Explain the practical applications of servomotors?	Remember	CO2	AEEB16.04
5	What is the basis for framing the rules of block diagram reduction technique? What are drawbacks of the block diagram reduction technique?	Remember	CO2	AEEB16.04
6	Explain properties of signal flow graphs? Explain the need of signal flow graph representation for any system	Understand	CO2	AEEB16.04
7	How do you construct a signal flow graph from the equations?	Understand	CO2	AEEB16.04
8	Explain briefly about mason's gain formula?	Remember	CO2	AEEB16.04
9	What are advantages of signal flow graph over block diagram?	Remember	CO2	AEEB16.04
10	Explain about various test signals used in control systems?	Remember	CO2	AEEB16.05
11	Derive the expression for time domain specification of a under damped second order system to a step input?	Understand	CO2	AEEB16.05
12	Derive the transient response of under damped second order system when excited by unit step input?	Understand	CO2	AEEB16.05
13	Derive the transient response of over damped second order system when excited by unit step input?	Remember	CO2	AEEB16.05
14	(a)How steady state error of a control system is determined? How it can be reduced? (b) Derive the static error constants and list the disadvantages?	Understand	CO2	AEEB16.05
15	For a system $G(s)H(s)=\frac{K}{S^2(S+2)(S+3)}$. Find the value of K to limit steady state error to 10 when input to system is $1+10t+\frac{40}{2}t^2$	Understand	CO2	AEEB16.05
16	Explain error constants K_p, K_v and K_a for type I system?	Understand	CO2	AEEB16.05
17	Explain the effect of P, PI, PD and PID control on the performance of control system?	Remember	CO2	AEEB16.06
18	What are P, D, and I controllers? Why D controller is not used in control systems?	Remember	CO2	AEEB16.06
19	Discuss the advantages and disadvantages of proportional, proportional derivative, proportional integral control system?	Remember	CO2	AEEB16.06
20	Derive the transient response of un damped second order system when excited by unit step input?	Remember	CO2	AEEB16.05

21	Derive the transient response of critically damped second order system when excited by unit step input?	Understand	CO2	AEEB16.05
22	Explain the effect of PD control on the performance of control system	Understand	CO2	
23	Explain error constants K_p, K_v and K_a for type II system.	Remember	CO2	AEEB16.05
24	What are generalized error constants? State the advantages and significance of generalized error constants?	Understand	CO2	AEEB16.05
Part - C (Problem Solving and Critical Thinking Questions)				
1	Determine the overall transfer function C(S)/R(S) for the system shown in fig 	Understand	CO2	AEEB16.04
2	Discuss Mason's gain formula. Obtain the overall transfer function C/R from the signal flow graph shown. 	Remember	CO2	AEEB16.04
3	Determine the transfer function C(S)/R(S) of the system shown below fig. 2.3 by block diagram reduction method 	Remember	CO2	AEEB16.04
4	Reduce the given block diagram and hence obtain the transfer function C(s)/R(s) 	Remember	CO2	AEEB16.04
5	For the signal flow graph shown below fig.1.4, find the overall gain  Fig. 1.4	Understand	CO2	AEEB16.04

6	Find the transfer function for the block diagram shown as below 	Understand	CO2	AEEB16.04
7	Find the overall gain C(s)/R(s) of the system shown below? 	Remember	CO2	AEEB16.04
8	Draw a signal flow graph and evaluate the closed-loop transfer function of a system whose block diagram is given as follows: 	Understand	CO2	AEEB16.04
9	Draw a signal flow graph and evaluate the closed-loop transfer function of a system whose block diagram is given as follows 	Understand	CO2	AEEB16.04
10	Find the closed loop transfer function of the system 	Remember	CO2	AEEB16.04

<table>
<tr><td>11</td><td>For the signal flow graph shown below fig.2.2 using Mason’s gain formula obtain C(s)/R(s).

</td><td>Remember</td><td>CO2</td><td>AEEB16.04</td></tr>
<tr><td>12</td><td>Find the closed loop transfer function using block diagram reduction technique for the block

</td><td>Remember</td><td>CO2</td><td>AEEB16.04</td></tr>
<tr><td>13</td><td>find the transfer function through the Mason’s gain formula for the figure given below

</td><td>Understand</td><td>CO2</td><td>AEEB16.04</td></tr>
<tr><td>14</td><td>Apply masons gain formula to find its transfer function.

</td><td>Understand</td><td>CO2</td><td>AEEB16.04</td></tr>
</table>

15	Determine the overall transfer function C(S)/R(S) for the system shown in fig 	Understand	CO2	AEEB16.04
16	Obtain the overall transfer function C/R from the signal flow graph shown. 	Understand	CO2	AEEB16.04
17	A unity feedback system has $G(s) = \frac{40(S+2)}{S(S+1)(S+4)}$ Determine (i) Type of the system (ii) All error coefficients and (iii) Error for the ramp input with magnitude 4	Understand	CO2	AEEB16.05
18	For a unity feedback system whose open loop transfer function is $G(s) = \frac{50}{(1+0.1s)(1+2s)}$, find the position, velocity & acceleration error Constants.	Understand	CO2	AEEB16.05
19	A unity feedback system is characterized by an open loop transfer function $G(s) = \frac{K}{S(S+10)}$ Determine gain 'K' so that system will have a damping ratio of 0.5. For this value of 'K' determine settling time, peak overshoot and time to peak overshoot for a unit step input. Also obtain closed loop response in time domain	Understand	CO2	AEEB16.05
20	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 be reduced so that the peck overshoot of unit step response of the system is reduced from 75% to 25%?	Understand	CO2	AEEB16.05
21	A unity feed-back system is characterized by the open-loop transfer function: $G(s) = \frac{1}{(1+0.5s)(1+0.2s)}$. Determine the steady-state errors for unity-step, unit-ramp and unit-acceleration input. Also find the damping ration and natural frequency of the dominant roots.	Understand	CO2	AEEB16.05
22	The forward transfer function of a unity feedback type1, second order system has a pole at -2. The nature of gain k is so adjusted that damping ratio is 0.4. The above equation is subjected to input r(t)=1+4t. Find steady state error?	Understand	CO2	AEEB16.05
23	A feedback control system is described as $G(s) = \frac{50}{s(s+2)(s+5)}, H(s) = \frac{1}{s}$ For a unit step input, determine the steady state error constants & errors.	Understand	CO2	AEEB16.05

24	The closed loop transfer function of a unity feedback control system is given by- $\frac{C(s)}{R(s)} = \frac{10}{s^2 + 4s + 5}$ Determine (i) Damping ratio (ii) Natural undammed resonance frequency (iii) Percentage peak overshoot (iv) Expression for error response	Remember	CO2	AEEB16.05
25	The open loop transfer function of a control system with unity feedback is given by $G(s) = \frac{100}{s(s+0.1s)}$. Determine the steady state error of the system when the input is $10+10t+4t^2$	Remember	CO2	AEEB16.05
26	For a system $G(s)H(s) = \frac{K}{s^2(s+2)(s+6)}$ Find the value of K to limit steady state error to 10 when input to system is $1 + 10t + \frac{40}{2}t^2$	Understand	CO2	AEEB16.05
27	A unity feedback system has $G(s) = \frac{40(s+2)}{s(s+3)(s+4)}$ Determine (i) Type of the system (ii) All error coefficients and (iii) Error for the ramp input with magnitude 4	Understand	CO2	AEEB16.05
28	The closed loop transfer function of a unity feedback control system is given by- $\frac{C(s)}{R(s)} = \frac{20}{s^2 + 16s + 25}$ Determine (i) Damping ratio (ii) Natural undammed resonance frequency (iii) Percentage peak overshoot (iv) Expression for error response	Remember	CO2	AEEB16.05
MODULE – III				
CONCEPT OF STABILITY AND ROOT LOCUS TECHNIQUE				
Part – A (Short Answer Questions)				
1	Define BIBO stability. What is the necessary condition for stability?	Understand	CO3	AEEB16.07
2	What is characteristic equation?	Understand	CO3	AEEB16.07
3	What is the relation between stability and coefficient of characteristic polynomial?	Understand	CO3	AEEB16.07
4	What will be the nature of impulse response when the roots of characteristic equation are lying on imaginary axis?	Remember	CO3	AEEB16.07
5	What will be the nature of impulse response if the roots of characteristic equation are lying on right half s-plane?	Understand	CO3	AEEB16.07
6	What is routh stability criterion?	Understand	CO3	AEEB16.07
7	What is auxiliary polynomial?	Understand	CO3	AEEB16.07
8	What is quadratic symmetry?	Understand	CO3	AEEB16.07
9	In routh array what conclusion you can make when there is a row of all zeros?	Understand	CO3	AEEB16.07
10	What is limitedly stable system?	Understand	CO3	AEEB16.07
11	Define absolute stability?	Understand	CO3	AEEB16.07

12	Define marginal stability?	Understand	CO3	AEEB16.07
13	Define conditional stability?	Understand	CO3	AEEB16.07
14	Define stable system?	Understand	CO3	AEEB16.07
15	Define Critically stable system?	Understand	CO3	AEEB16.07
16	Define conditionally stable system?	Understand	CO3	AEEB16.07
17	For the represented by the following characteristic equation say whether the necessary condition for stability is satisfied or not $s^4+3s^3+4s^2+5s+10=0$	Understand	CO3	AEEB16.07
18	For the represented by the following characteristic equation say whether the necessary condition for stability is satisfied or not $s^4+3s^3+4s^2+5s+10=0$	Understand	CO3	AEEB16.07
19	For the represented by the following characteristic equation say whether the necessary condition for stability is satisfied or not $s^6-2s^5+s^3+s^2+s+6=0$	Understand	CO3	AEEB16.07
20	For the represented by the following characteristic equation say whether the necessary condition for stability is satisfied or not $s^5+4s^4-5s^3-4s^2+2s+1=0$	Understand	CO3	AEEB16.07
21	How the roots of characteristic equation are related to stability?	Understand	CO3	AEEB16.07
22	For the represented by the following characteristic equation say whether the necessary condition for stability is satisfied or not $5s^4+4s^2+5s+10=0$	Understand	CO3	AEEB16.07
23	For the represented by the following characteristic equation say whether the necessary condition for stability is satisfied or not $3s^3+4s^2+5s+10=0$	Understand	CO3	AEEB16.07
24	For the represented by the following characteristic equation say whether the necessary condition for stability is satisfied or not $s^6+2s^5+3s^3+s^2+s+6=0$	Understand	CO3	AEEB16.07
25	For the represented by the following characteristic equation say whether the necessary condition for stability is satisfied or not $s^5+4s^4-5s^3-6s^2+2s+1=0$	Understand	CO3	AEEB16.07
26	What is root locus? How will you find root locus on real axis?	Understand	CO3	AEEB16.07
27	What are asymptotes?	Understand	CO3	AEEB16.07
28	What is centroid, how it is calculated?	Remember	CO3	AEEB16.07
29	What is breakaway point?	Remember	CO3	AEEB16.07
30	What is dominant pole?	Remember	CO3	AEEB16.07
31	What is break in point?	Remember	CO3	AEEB16.07
32	Determine poles for G(S)=40/S(s+4)(s+5)	Remember	CO3	AEEB16.07
33	Determine poles for G(S)=40/S(s+6)(s+2)	Understand	CO3	AEEB16.07
34	Determine the zeros for G(S)=40(s+2)(s+6)/(s+4)(s+5)	Understand	CO3	AEEB16.07
35	Determine the zeros for G(S)=10(s+6)(s+8)/(s+3)(s+2)	Understand	CO3	AEEB16.07
36	How will you find the gain K at a point on root locus?	Understand	CO3	AEEB16.07
	Part – B (Long Answer Questions)			
1	Define the terms (i) Absolute stability (ii) marginal stability (iii) conditional stability (iv) stable system(v) Critically stable system (vi) conditionally stable system?	Remember	CO3	AEEB16.07
2	State and explain the advantages and limitations of Routh Hurwitz criteria.	Understand	CO3	AEEB16.07
3	What are the necessary conditions to have all the roots of characteristics equation in the left half of s-plane?	Remember	CO3	AEEB16.07

4	Determine the stability of the system represented by characteristic equation ,$s^4+2s^3+8s^2+4s+3=0$ using Routh criterion.	Remember	CO3	AEEB16.07
5	The open loop transfer function of a unity feedback system is given by $G(s) = \frac{K}{S(1+0.25S)(1+0.4S)}$. Find the restriction on k so that the closed loop system is absolutely stable.	Understand	CO3	AEEB16.07
6	Examine the stability of the given characteristic equation using Routh's method $S^6+2S^5+8S^4+12S^3+20S^2+16S+16=0$	Understand	CO3	AEEB16.07
7	Locate the poles and zeros on the S-plane of a system $G(s)=13(s+7)(s+9)/(s^2+5s+8)$	Remember	CO3	AEEB16.07
8	Using the routh's criterion determine the stability of the system represented by characteristic equation $s^4+8s^3+18s^2+16s+5=0$	Understand	CO3	AEEB16.07
9	Using the routh's criterion determine the stability of the system represented by characteristic equation $s^7+9s^6+24s^5+24s^3+24s^2+23s+15$	Remember	CO3	AEEB16.07
10	Using the routh's criterion determine the stability of the system represented by characteristic equation $s^4+s^3+5s^2+4s+4=0$	Remember	CO3	AEEB16.07
11	Using the routh's criterion determine the stability of the system represented by characteristic equation $s^7+9s^6+24s^5+24s^3+24s^2+23s+15$	Remember	CO3	AEEB16.07
12	Using the routh's criterion determine the stability of the system represented by characteristic equation $s^4+s^3+5s^2+4s+4=0$	Remember	CO3	AEEB16.07
13	The characteristic equation for certain feedback control systems is given below $s^4+4s^3+13s^2+36s+k=0$.determine the range of k for the system to be stable.	Remember	CO3	AEEB16.07
14	The open loop transfer function of a unity feedback system is given by $G(s) = K/S(S^2+s+1)(s+2)$ .find the range of K system will oscillate and what is frequency of oscillation	Remember	CO3	AEEB16.07
15	The open loop transfer function of a unity feedback system is given by $G(s) = \frac{K(s+13)}{S(s+3)(s+7)}$.find the restriction on k so that the closed loop system is stable.	Remember	CO3	AEEB16.07
16	Explain the steps for the construction of root locus?	Remember	CO3	AEEB16.08
17	What is break away and break in points? how to determine them?	Remember	CO3	AEEB16.08
18	The open loop transfer function of a control system is given by G(s) H(s) $=\frac{K}{S(S+6)(S^2+4S+13)}$ sketch complete root locus.	Understand	CO3	AEEB16.08
19	Write down the important rules for construction of root locus.	Understand	CO3	AEEB16.08
20	Sketch the root locus $G(S)=K/s(s^2+6s+10)$, $H(S)=1$	Understand	CO3	AEEB16.08
21	Construct the routh array for the unity feedback system $G(s)=10/s(s+2)(s+4)(s+6)$	Remember	CO3	AEEB16.08
22	What is centroid? How to calculate it?	Remember	CO3	AEEB16.08
23	state the effect of addition of poles and zeros on root locus and the stability of the system	Remember	CO3	AEEB16.09
Part - C (Problem Solving and Critical Thinking Questions)				
1	With the help of Routh Hurwitz criterion comments upon the stability of the system having the following characteristic equation $S^6+s^5-2s^4-3s^3-7s^2-4s-4=0$	Understand	CO3	AEEB16.07
2	How many roots does the following polynomials have in the right half of the s-plane $s^4+2s^3+4s^2+8s+15$	Understand	CO3	AEEB16.07

3	The system having characteristic equation 2 $s^4+4s^2+1=0$. Find (i) the number of roots in the left half of s-plane (ii) the number of roots in the right half of s-plane (iii)The number of roots on imaginary axis use RH stability criterion.	Remember	CO3	AEEB16.07
4	A unity feedback system has an open loop transfer function $G(s)=\frac{K}{(s+2)(s^2+4s+5)}$. Use RH test to determine the range of positive values of K for which the system is stable	Remember	CO3	AEEB16.07
5	Find the range of K for stability of the system with characteristic equation $s^4+3s^3+3s^2+2s+k=0$.	Understand	CO3	AEEB16.07
6	For the unity feedback system the open loop T.F. is $G(s)=\frac{K}{S(1+0.6S)(1+0.4S)}$ Determine range of values of K, marginal K and frequency of sustained oscillations	Understand	CO3	AEEB16.07
7	Using the routh's criterion determine the stability of the system represented by characteristic equation $s^5+s^4+2s^3+2s^2+3s+5=0$. Also determine the roots lying on the right half of the s-plane	Understand	CO3	AEEB16.07
8	Sketch the Root Locus for the unity feedback system with $$G(s)H(s)=\frac{K}{S(S+1)(S+3)(S+6)}$$ Find the breakaway point on real axis and find K of damping ratio=0.5	Understand	CO3	AEEB16.08
9	Sketch the complete Root Locus of the system $$G(s)=\frac{K}{S(S+2)(S^2+4S+13)}$$	Understand	CO3	AEEB16.08
10	Sketch root locus plot for unity feedback system whose open loop T.F is given by $G(S)=\frac{k(s+0.5)}{s^2(s+4.5)}$	Understand	CO3	AEEB16.08
11	Sketch the root locus plot of a unity feedback system whose open loop T.F is $G(s)=\frac{s}{(s^2+4)(s+2)}$	Understand	CO3	AEEB16.08
12	Construct the routh array for the unity feedback system G(s)=10/s(s+2)(s+6)(s+7)	Remember	CO3	AEEB16.07
13	Sketch the root locus of open loop transfer function given below? $G(s)=\frac{K}{S(S+3)(S^2+2S+2)}$	Understand	CO3	AEEB16.08
14	Sketch the root locus of open loop transfer function given below? $G(s)=\frac{K}{S(S^2+8S+20)}$	Remember	CO3	AEEB16.08
15	Sketch the root locus of open loop transfer function given below? $G(s)=\frac{K}{S(S+2)(S^2+2S+2)}$	Remember	CO3	AEEB16.08
MODULE -IV				
FREQUENCY DOMAIN ANALYSIS				
Part – A (Short Answer Questions)				
1	Define frequency response? With advantages of frequency response analysis?	Remember	CO4	AEEB16.10
2	Define frequency domain specifications?	Understand	CO4	AEEB16.10
3	Define Resonant Peak.	Understand	CO4	AEEB16.10
4	Define Bode plot? What are the advantages of Bode Plot?	Understand	CO4	AEEB16.10
5	Define gain margin and phase margin?	Understand	CO4	AEEB16.10
6	Define corner frequency.	Remember	CO4	AEEB16.10

7	Explain Gain cross-over frequency and phase cross-over frequency?	Remember	CO4	AEEB16.10
8	What is polar plot?	Understand	CO4	AEEB16.10
9	Define Bandwidth?	Remember	CO4	AEEB16.10
10	What are advantages of frequency response analysis?	Understand	CO4	AEEB16.10
11	Write the expression for resonant peak?	Remember	CO4	AEEB16.10
12	What is cut-off rate?	Remember	CO4	AEEB16.10
13	Write the expression for resonant frequency?	Remember	CO4	AEEB16.10
14	Define corner frequency?	Remember	CO4	AEEB16.10
15	Define polar plot?	Understand	CO4	AEEB16.11
16	What is nyquist plot?	Remember	CO4	AEEB16.11
	Part – B (Long Answer Questions)			
1	What is frequency response? What are advantages of frequency response analysis?	Understand	CO4	AEEB16.10
2	Write short notes on various frequency domain specifications	Understand	CO4	AEEB16.10
3	Explain the steps for the construction of Bode plot? What are the advantages of Bode Plot?	Understand	CO4	AEEB16.10
4	Sketch the Bode plot for the open loop transfer function $G(s) = \frac{10(S+3)}{S(S+2)(S^2+4S+100)}$	Understand	CO4	AEEB16.10
5	The open loop transfer function of a system is $G(s) = \frac{K}{S(1+S)(1+0.1S)}$ Determine the value of K such that (i) Gain Margin = 10dB and (ii) Phase Margin = 50 degree	Remember	CO4	AEEB16.10
6	For H(s)=1, $G(s) = \frac{Ke^{-0.2s}}{s(s+2)(s+8)}$. Determine K so that (i) phase margin is 45^0 (ii.) value of k for the gain margin to be 10db	Remember	CO4	AEEB16.10
7	Given the open loop transfer function $\frac{20}{s(1+3s)(1+4s)}$. Draw the Bode plot and hence the phase and gain margins.	Understand	CO4	AEEB16.10
8	Sketch the bode plot for a system with unity feedback having the transfer function, and assess its closed-loop stability. $G(s) = \frac{75}{S(s^2+16s+100)}$	Understand	CO4	AEEB16.10
9	Sketch the bode plot for a system with unity feedback having the transfer function, and assess its closed-loop stability. $G(s) = \frac{10}{S(1+0.4s)(1+0.1s)}$	Understand	CO4	AEEB16.10
10	Derive expression for resonant peak and resonant frequency and hence establish correlation between time and frequency response.	Remember	CO4	AEEB16.10
11	Define the following terms i) Gain cross over frequency ii) Resonant peak iii) Resonant frequency iv) Band width		CO4	AEEB16.10
12	Sketch the bode plot for a system with unity feedback having the transfer function, and assess its closed-loop stability. $G(s) = \frac{50(1+0.1S)}{S(1+0.01S)(1+S)}$	Understand	CO4	AEEB16.10

13	Sketch the bode plot for a system with unity feedback having the transfer function, and assess its closed-loop stability. $$G(s) = \frac{30(1+0.1S)}{S(1+0.01s)(1+s)}$$	Understand	CO4	AEEB16.10
14	Sketch the bode plot for a system with unity feedback having the transfer function, and assess its closed-loop stability. $$G(s) = \frac{100(1+0.1S)}{S(1+0.2s)(1+0.5s)}$$	Understand	CO4	AEEB16.10
15	Sketch the bode plot for a system with unity feedback having the transfer function, and assess its closed-loop stability. $$G(s) = G(s) = \frac{40(1+s)}{(1+5s)(s^2+2s+4)}$$	Understand	CO4	AEEB16.10
16	Draw the polar plot for open loop transfer function for unity feedback system $G(s)=\frac{1}{s(1+s)(1+2s)}$. Also determine gain margin, phase margin?	Understand	CO4	AEEB16.11
	Part - C (Problem Solving and Critical Thinking Questions)			
1	Given damping ratio ξ=0.7 and ω_n=10 rad/sec find the resonant peak, resonant frequency and band width.	Remember	CO4	AEEB16.10
2	For a second order system with unity feedback G(s)=$\frac{200}{s(s+8)}$.find various frequency domain specifications.	Remember	CO4	AEEB16.10
3	Sketch bode plot of a system G(s)=$\frac{1}{(1+s)(1+2s)}$	Understand	CO4	AEEB16.10
4	Draw the exact bode plots and find the gain margin and phase margin of a system represented by G(s)H(s)=$\frac{10(s+1)}{s\,(s+0.05)(s+3)(s+5)}$	Understand	CO4	AEEB16.10
5	Draw the exact bode plots and find the gain margin and phase margin of a system represented by G(s)=$\frac{10(s+1)}{s\,(s+0.05)(s+3)(s+5)}$,H(S)=1	Understand	CO4	AEEB16.10
6	The open loop transfer function of a unity feedback system is G(s) =$\frac{50K}{s\,(s+10)(s+5)(s+1)}$ find the gain margin and phase margin using bode plot?	Understand	CO4	AEEB16.10
7	Sketch the bode plot for transfer function G(s)= $\frac{Ks^2}{(1+0.2s)(1+0.02s)}$and find value of K such that gain cross over frequency is 5 rad/sec	Understand	CO4	AEEB16.10
8	Sketch the bode plot or a system G(s) =$\frac{15(s+5)}{s\,(s^2+16s+100)}$.hence determine the stability of the system.	Remember	CO4	AEEB16.10
9	Sketch the bode plots of G(s)=$\frac{e^{-0.1s}28.5}{s(1+s)(1+0.1s)}$.hence find the gain cross over frequency	Understand	CO4	AEEB16.10
10	A unity feedback control system has G(s)=$\frac{K}{s(s+1)(1+\frac{s}{10})}$.find the value of K so that GM=12db and PM=30deg.	Understand	CO4	AEEB16.10
11	Given damping ratioξ=0.8 and ω_n=10 rad/sec find the resonant peak, resonant frequency and band width	Understand	CO4	AEEB16.10
12	For a second order system with unity feedback G(s) =$\frac{200}{s(s+6)}$.find various frequency domain specifications.	Understand	CO4	AEEB16.10
13	Calculate the damping ratio and natural frequency of second order system is 0.5 and 8 rad/sec respectively. Calculate the resonant peak and resonant frequency?	Understand	CO4	AEEB16.10
14	Sketch the bode plots of G(s) =$\frac{Ke^{-0.2s}}{s(S+2)(S+8)}$..Find k so that the system is stable with,(a) gain margin equal to 2db (b)phase margin equal to 45deg	Understand	CO4	AEEB16.10

15	Sketch the bode plot for a system with unity feedback having the transfer function, and assess its closed-loop stability. $$G(s) = \frac{30}{S(1+3s)(1+4s)}$$	Remember	CO4	AEEB16.10
16	Sketch polar plot for G(S) = $\frac{1}{S^2(1+s)(1+2s)}$ with unity feedback system. Determine gain margin and phase margin.	Understand	CO4	AEEB16.11
17	Obtain the range of values of K for which the following open loop transfer function is stable use nyquist stability criterion .G(S)H(S)=K(S+1)/$S^2(s+2)(s+4)$	Understand	CO4	AEEB16.11
18	Obtain the range of values of K for which the following open loop transfer function is stable use nyquist stability criterion .G(S)H(S)=K/s(s^2 +2s+2).	Understand	CO4	AEEB16.11
MODULE -V				
STATE SPACE ANALYSIS AND COMPENSATORS				
Part - A (Short Answer Questions)				
1	What are the advantages of state space analysis?	Remember	CO5	AEEB16.13
2	What are draw backs of transfer function model analysis	Understand	CO5	AEEB16.13
3	Define state?	Understand	CO5	AEEB16.13
4	Define state variable?	Understand	CO5	AEEB16.13
5	Define state vector??	Understand	CO5	AEEB16.13
6	What are the properties of state transition matrix?	Understand	CO5	AEEB16.13
7	Write resolving matrix?	Remember	CO5	AEEB16.13
8	Define observability?	Understand	CO5	AEEB16.13
9	Define controllability?	Understand	CO5	AEEB16.13
10	How the modal matrix can be determined?	Understand	CO5	AEEB16.13
11	What is i/p and o/p space?	Understand	CO5	AEEB16.13
12	What are eigen values?	Understand	CO5	AEEB16.15
13	What is lead compensator?	Understand	CO5	AEEB16.15
14	What is lag compensator?	Understand	CO5	AEEB16.15
15	What is lag-lead compensator?	Understand	CO5	AEEB16.15
16	What are draw backs of transfer function model analysis?	Understand	CO5	AEEB16.14
17	What is state, state variable and state vector?	Understand	CO5	AEEB16.14
Part – B (Long Answer Questions)				
1	Explain the state variable and state transition matrix?	Understand	CO5	AEEB16.13
2	Write shot notes on formulation of state equations?	Remember	CO5	AEEB16.13
3	Derive the expression for the calculation of the transfer function from the state variables for the analysis of system?	Understand	CO5	AEEB16.13
4	Write short notes on canonical form of representation .list its advantages and disadvantages?	Understand	CO5	AEEB16.13
8	Write properties of state transition matrix?	Remember	CO5	AEEB16.14
9	State and explain controllability and observability?	Remember	CO5	AEEB16.14

10	Obtain the state transition Matrix for a system matrix given by $A=\begin{bmatrix}0 & 1\\ -2 & -3\end{bmatrix}$	Understand	CO5	AEEB16.14
11	The transfer function of a control system given by $\frac{C(s)}{R(s)}=\frac{6(s+1)}{s(s+2)(s+3)}$. Construct three different state models for this system and draw realization structure for any one of the state models.	Understand	CO5	AEEB16.13
12	Write the necessary and sufficient conditions for complete state controllability and observability?	Understand	CO5	AEEB16.14
13	Given G(S) = $(1+T_1S)/(1+T_2S)$ What should be the relationship between T_1 & T_2, if a. G(S) is a lag network b. G(S) is a lead network c. Determine expression for magnitude response and calculate the magnitude at a frequency $\omega = 1/T_2$	Understand	CO5	AEEB16.14
14	Obtain the state space model of a series RLC circuit.	Understand	CO5	AEEB16.14
	Part - C (Problem Solving and Critical Thinking Questions)			
1	Linear time invariant system is described by the following state model. Obtain the canonical form of the state model. $\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix}=\begin{bmatrix}-1 & 1\\ 1 & -2\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}+\begin{bmatrix}0\\ 1\end{bmatrix}$u and y=$[1/3 \quad -1/3]$	Understand	CO5	AEEB16.13
2	convert the following system matrix to canonical form A=$\begin{bmatrix}1 & 2 & 1\\ -1 & 0 & 2\\ 1 & 3 & -1\end{bmatrix}$	Remember	CO5	AEEB16.13
3	A linear time invariant system is described by the following state model.obtain the canonical form of state model $\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix}=\begin{bmatrix}-1 & 0\\ 0 & -3\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}+\begin{bmatrix}1\\ 1\end{bmatrix}$u and y=$[-1 \quad -2]\begin{bmatrix}x_1\\ x_2\end{bmatrix}$	Understand	CO5	AEEB16.13
4	Convert the following system matrix to canonical form and hence calculate the STM. A=$\begin{bmatrix}4 & 1 & -2\\ 1 & 0 & 2\\ 1 & -1 & 3\end{bmatrix}$	Understand	CO5	AEEB16.13
5	A system variables for the state variable representation of the system are, A=$\begin{bmatrix}-1 & 1\\ 1 & -2\end{bmatrix}$,B=$\begin{bmatrix}0\\ 1\end{bmatrix}$, $C=[1 \quad 0]$ Determine the complete state response and the output response of the system for the initial state X(0)=$\begin{bmatrix}-1\\ 0\end{bmatrix}$	Remember	CO5	AEEB16.14
6	For the state equation $\dot{x}$=Ax, find the intial condition vector x(0) which will excite only the mode corresponding to eigen value with the most negative real part. Where A=$\begin{bmatrix}0 & 1 & 0\\ 3 & 0 & 2\\ -12 & -7 & -6\end{bmatrix}$.	Understand	CO5	AEEB16.14
7	Consider the differential equation system given by $2\dddot{y}+3\ddot{y}+5\dot{y}+2y=u$ y(0)=0.1,y(0)=0.05. Obtain the response y(t),subjected to the given intial condition	Understand	CO5	AEEB16.14

8	determine the state controllability and observability of the following system $\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix}=\begin{bmatrix}-3 & -1\\ -2 & 1.5\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}+\begin{bmatrix}1\\ 4\end{bmatrix}u$ C=[0 1]	Remember	CO5	AEEB16.14
9	examine the observability of the system given below using canonical form $\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix}=\begin{bmatrix}0 & 1 & 0\\ 0 & 1 & 1\\ 0 & -2 & -3\end{bmatrix}\begin{bmatrix}x1\\ x2\\ x3\end{bmatrix}+\begin{bmatrix}0\\ 0\\ 1\end{bmatrix}u$ $Y=[3\ 4\ 1]\begin{bmatrix}x1\\ x2\\ x3\end{bmatrix}$	Understand	CO5	AEEB16.14
10	Design a suitable lag compensator for a system with, $G(S) = \frac{4}{S(S+2)}$ to meet the specifications as a. $K_v \geq 5\ sec^{-1}$ b. P. M $\geq +40^0$ c. G.M. $\geq$ +10 db.	Remember	CO5	AEEB16.15
11	Design a lead compensator using root locus for the system with , $G(S) = \frac{4}{S(S+2)}$ to meet the specifications as a. Damping ratio = 0.5 b. setting time = 2 sec.	Understand	CO5	AEEB16.15
12	Design a suitable lag compensator root locus for the system with, $G(S) = \frac{K}{S(S+1)(S+2)}$ to meet the specifications as a. Damping ratio = 0.5 b. $K_v \geq 5\ sec^{-1}$ c. Undamped natural frequency = 0.7 rad/sec	Remember	CO5	AEEB16.15

Prepared By:

Dr. M. Pala Prasad Reddy, Associate Professor

HOD, ECE