Ref No:

Sri Krishna Institute of Technology, Bangalore

COURSE PLAN

Academic Year 2019-2020

Program:	B E – Electronics & Communication Engineering
Semester :	4
Course Code:	18EC43
Course Title:	Control Systems
Credit / L-T-P:	3 / 3-0-0
Total Contact Hours:	40
Course Plan Author:	ARUN KUMAR R

Academic Evaluation and Monitoring Cell

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A. COURSE INFORMATION

1. Course Overview

Degree:	BE	Program:	EC
Semester:	4	Academic Year:	2019-20
Course Title:	CONTROL SYSTEMS	Course Code:	18EC43
Credit / L-T-P:	3 / 3-0-0	SEE Duration:	180 Minutes
Total Contact Hours:	40 Hours	SEE Marks:	100 Marks
CIA Marks:	30 Marks	Assignment	1 / Module
Course Plan Author:	ARUN KUMAR R	Sign ..	Dt:16/12/2019
Checked By:		Sign ..	Dt:
CO Targets	CIA Target : ...... %	SEE Target:	.... %

Note: Define CIA and SEE % targets based on previous performance.

2. Course Content

Content / Syllabus of the course as prescribed by University or designed by institute.

Module	Content	Teaching Hours	Blooms Learning Levels
1	**Introduction to Control Systems:** Types of Control Systems, Effect of Feedback Systems, Differential equation of Physical Systems –Mechanical Systems, Electrical Systems, Electromechanical systems, Analogous Systems.	10 hours	**L1, L2, L3**
2	**Block diagrams and signal flow graphs:** Transfer functions, Block diagram algebra and Signal Flow graphs.	10 hours	**L1, L2, L3**
3	**Time Response of feedback control systems:** Standard test signals, Unit step response of First and Second order Systems. Time response specifications, Time response specifications of second order systems, steady state errors and error constants. Introduction to PI, PD and PID Controllers (excluding design).	10 hours	**L1, L2, L3**
4	**Stability analysis:** Concepts of stability, Necessary conditions for Stability, Routhstability criterion, Relative stability analysis: more on the Routh stability criterion. Introduction to Root-Locus Techniques, The root locus concepts, Construction of rootloci. **Frequency domain analysis and stability:** Correlation between time and frequency response, Bode Plots, Experimental determination of transfer function.	10 hours	**L1, L2, L3**
5	Introduction to Polar Plots, (Inverse Polar Plots excluded) Mathematical preliminaries, Nyquist Stability criterion, (System s with transportation lag excluded) Introduction to lead, lag and lead- lag compensating networks (excluding design). **Introduction to State variable analysis:** Concepts of state, state variable and state models for electrical systems, Solution of state equations.	10 hours	**L1, L2, L3**
-	**Total**	**50**	

3. Course Material

Books & other material as recommended by university (A, B) and additional resources used by course teacher (C).

1. Understanding: Concept simulation / video ; one per concept ; to understand the concepts ; 15 – 30 minutes
2. Design: Simulation and design tools used – software tools used ; Free / open source
3. Research: Recent developments on the concepts – publications in journals; conferences etc.

Modules	Details	Chapters in book	Availability

A	**Text books (Title, Authors, Edition, Publisher, Year.)**	-	-
1, 2, 3, 4, 5	Text Book: J.Nagarath and M.Gopal, — Control Systems Engineering‖, New Age International (P) Limited, Publishers, Fifth edition-2005, ISBN: 81-224-2008-7.	2,3,5,6,7, 9,12	In Lib / In Dept
B	**Reference books (Title, Authors, Edition, Publisher, Year.)**	-	-
1,2,3,4, 5	Reference Books: 1. —Modern Control Engineering,‖ K.Ogata, Pearson Education Asia/PHI, 4th Edition, 2002. ISBN 978-81-203-4010-7.	1,3,5,6,7 ,8,11	In Lib
1,2,3,4, 5	2. —Automatic Control Systems‖, Benjamin C. Kuo, John Wiley India Pvt. Ltd., 8th Edition, 2008. 3. —Feedback and Control System,‖ Joseph J Distefano III et al., Schaum's Outlines, TMH, 2nd Edition 2007.	1,3,5,7,8 ,10	In Lib
1,2,3,4, 5	"Feedback and Control System," Joseph J Distefano III et al., Schaum'sOutlines, TMH, 2 nd Edition 2007.	1,3,5,6,7 ,8,11,13, 15,	In Lib
C	**Concept Videos or Simulation for Understanding**	-	-
C1	https://www.youtube.com/watch?v=Wv2MgI2sFkM&list=PL4K9r9dYCOopjw3dyiZ8wdPDuXHIvGHSq		
C2	https://www.youtube.com/watch?v=WrVk_lT60dk		
C3	https://www.youtube.com/watch?v=Jlz_C-OO5m8 https://www.youtube.com/watch?v=sFqFrmMJ-sg		
C4	https://www.youtube.com/watch?v=nqbCgOV_oH4 https://www.youtube.com/watch?v=72y_uQ8A0e8 https://www.youtube.com/watch?v=hyDR25WhZ44		
C5	https://www.youtube.com/watch?v=DSvBXXnZv34&list=PLW6YlvHa65xg5asFyEm6hx0wjHNcaVpTT		
D	**Software Tools for Design**	-	-
	matlab		
E	**Recent Developments for Research**	-	-
	https://www.youtube.com/watch?v=_5TG_zQny2E		
	https://www.youtube.com/watch?v=Vu6zR5yN430		
F	**Others (Web, Video, Simulation, Notes etc.)**	-	-
1	https://www.youtube.com/watch?v=7LZSjgZz-Qw&list=PLxn52v8fxX5l5tGzU1NAxRDkgqxK0k5UZ		
2	https://www.youtube.com/watch?v=XMfH2P2Fc6Q&list=PLWPirh4EWFpGpH_Rb6Q4iQ6vGGRA6MORZ		

4. Course Prerequisites

Refer to GL01. If prerequisites are not taught earlier, GAP in curriculum needs to be addressed. Include in Remarks and implement in B.5.

Students must have learnt the following Courses / Topics with described Content . . .

Modules	Course Code	Course Name	Topic / Description	Sem	Remarks	Blooms Level
1	18MAT31	Transform Calculus, Fourier Series And Numerical Techniques	Laplace Transformation	3		Apply L3
2	18EC32	Network Analysis	KVL, KCL	3		Apply L3

5. Content for Placement, Profession, HE and GATE

The content is not included in this course, but required to meet industry & profession requirements and help students for Placement, GATE, Higher Education, Entrepreneurship, etc. Identifying Area / Content requires experts consultation in the area.
Topics included are like, a. Advanced Topics, b. Recent Developments, c. Certificate Courses, d. Course Projects, e. New Software Tools, f. GATE Topics, g. NPTEL Videos, h. Swayam videos etc.

Modules	Topic / Description	Area	Remarks	Blooms Level
1	Transformation of mathematical modeling using MATLAB	Control engineering	Required for higher education	L2
3	Transient response analysis using MATLAB	Control engineering	Required for higher education	L2
4	Root-Locus Techniques using MATLAB	Control engineering	Required for higher education	L2
5	Transformation of system models using MATLAB	Control engineering	Required for higher education	L2

B. OBE PARAMETERS

1. Course Outcomes

Expected learning outcomes of the course, which will be mapped to POs.

Modules	Course Code.#	Course Outcome **At the end of the course, student should be able to . . .**	Teach. Hours	Instr Method	Assessment Method	Blooms' Level
1	18EC43.1	Apply mathematical modeling to determine the transfer function of a system.	10	Lecture/ Tutorial	Assignment / CIA	L_2 – Understanding L_3 – Applying
2	18EC43.2	Apply block diagram reduction technique and signal flow graph reduction methods to determine the transfer function of a system	10	Lecture/ Tutorial	Assignment / CIA	L_2 – Understanding L_3 – Applying
3	18EC43.3	: Analyze the behavior of the system in time domain for 1st and 2nd order systems and PID controllers	10	Lecture/ Tutorial	Assignment / CIA	L_2 – Understanding L_3 – Applying
4	18EC43.4	Analyze the stability of the system using various time domain and bode plot technique	10	Lecture/ Tutorial	Assignment / CIA	L_2 – Understanding L_3 – Applying
5	18EC43.5	Analyze the stability of the system using frequency domain techniques and Analyze the electrical system using state variable technique.	10	Lecture/ Tutorial	Assignment / CIA	L_3 – Applying, L_4 – Analysing
-	**-**	**Total**	**50**	**-**	**-**	**L2-L4**

2. Course Applications

Write 1 or 2 applications per CO.
Students should be able to employ / apply the course learnings to . . .

Modules	Application Area Compiled from Module Applications.	CO	Level

1	Used in steam generator design	1	L2
2	Used in single-input single-output filters in the fields of signal processing	2	L4
3	Practical application to the measurement of phase noise and jitter, Used in digital temperature controller	3	L3 L2
4	Used in ilinear time-invariant systems. Used to design the damping ratio and natural frequency of a feedback system. The plot can be used to interpret how the input affects the output in both magnitude and phase over frequency.	4	L2 L3 L3
5	Used in Design of model based controllers such as MPC,	5	L2

3. Articulation Matrix

CO – PO Mapping with mapping level for each CO-PO pair, with course average attainment.

-	-	Course Outcomes	Program Outcomes															-
Modules	CO.#	**At the end of the course student should be able to . . .**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	Level
1	18EC43.1	Apply mathematical modeling to determine the transfer function of a system.	3	3	2									3	3			
2	18EC43.2	Apply block diagram reduction technique and signal flow graph reduction methods to determine the transfer function of a system	3	3	2									3	3			
3	18EC43.3	: Analyze the behavior of the system in time domain for 1st and 2nd order systems and PID controllers	3	3	2									3	3			
4	18EC43.4	Analyze the stability of the system using various time domain and bode plot technique	3	3	2	2								3	3			
5	18EC43.5	Analyze the stability of the system using frequency domain techniques and Analyze the electrical system using state variable technique.	3	3	2	2								3	3			
-	**18CE43.**	Average	**3**	**3**	**2**	**2**								**3**	**3**			**-**
-	*PO, PSO*	*1.Engineering Knowledge; 2.Problem Analysis; 3.Design / Development of Solutions; 4.Conduct Investigations of Complex Problems; 5.Modern Tool Usage; 6.The Engineer and Society; 7.Environment and Sustainability; 8.Ethics; 9.Individual and Teamwork; 10.Communication; 11.Project Management and Finance; 12.Life-long Learning; S1.Software Engineering; S2.Data Base Management; S3.Web Design*																

4. Curricular Gap and Content

Topics & contents not covered (from A.4), but essential for the course to address POs and PSOs.

Modules	Gap Topic	Actions Planned	Schedule Planned	Resources Person	PO Mapping
1	Transformation of mathematical modeling using MATLAB	Seminar	3rd week of March 2020	Concerned faculty	PO5
3	Transient response	Seminar	3rd week of	Concerned faculty	PO5

	analysis using MATLAB		April 2020		
4	Root-Locus Techniques using MATLAB	Seminar	2nd week of May 2020	Concerned faculty	PO5
5	Transformation of system models using MATLAB	Seminar	4th week of May 2020	Concerned faculty	PO5

C. COURSE ASSESSMENT

1. Course Coverage

Assessment of learning outcomes for Internal and end semester evaluation.

Modules	Title	Teach. Hours	No. of question in Exam						CO	Levels
			CIA-1	CIA-2	CIA-3	Asg	Extra Asg	SEE		
1	**Introduction to Control System**	10	2	-	-	1	1	2	CO1	L2, L3
2	**Block diagrams and signal flow graphs**	10	2	-	-	1	1	2	CO2	L2, L3
3	**Time Response of feedback control systems**	10	-	2	-	1	1	2	CO3	L2, L3
4	**Stability analysis Frequency domain analysis and stability**	10	-	2	-	1	1	2	CO4	L2, L3
5	Introduction to Polar Plots, **Introduction to State variable analysis**	10	-	-	4	1	1	2	CO5	L3, L4
-	**Total**	**50**	**4**	**4**	**4**	**5**	**5**	**10**	**-**	**-**

2. Continuous Internal Assessment (CIA)

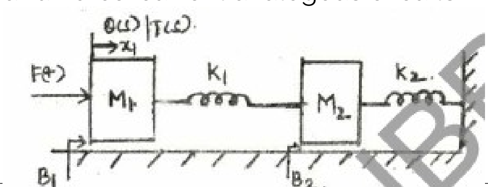
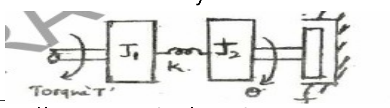
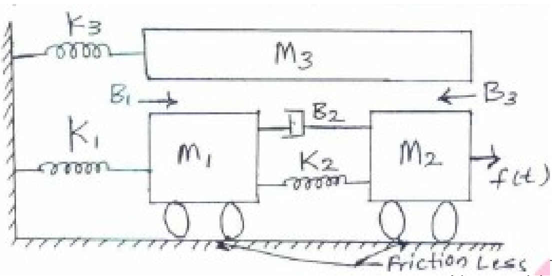
Assessment of learning outcomes for Internal exams. Blooms Level in last column shall match with A.2.

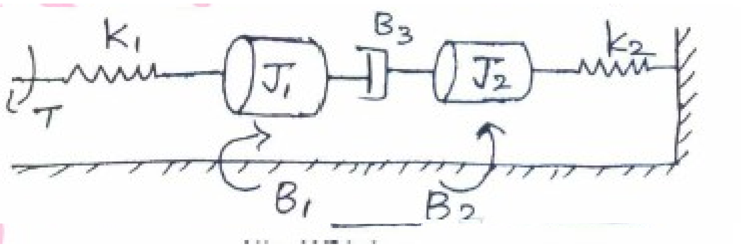
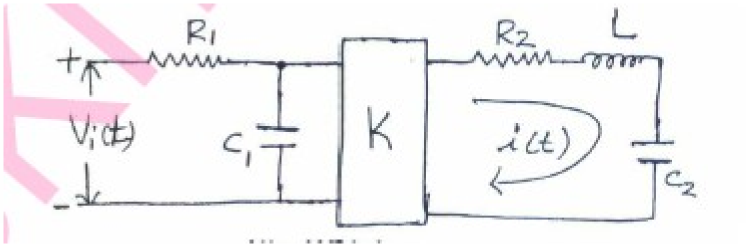
Modules	Evaluation	Weightage in Marks	CO	Levels
1, 2	CIA Exam – 1	30	CO1, CO2	L2,L3
3, 4	CIA Exam – 2	30	CO3,Co4	L2,L3
5	CIA Exam – 3	30	CO5	L2,L4
1, 2	Assignment - 1	10	CO1, CO2	L2,L3
3, 4	Assignment - 2	10	CO3,Co4	L2,L3
5	Assignment - 3	10	CO5	L2,L4
1, 2	Seminar - 1		-	-
3, 4	Seminar - 2		-	-
5	Seminar - 3		-	-
1, 2	Quiz - 1		-	-
3, 4	Quiz - 2		-	-
5	Quiz - 3		-	-
1 - 5	Other Activities – Mini Project	-	-	-
	Final CIA Marks	**40**	**-**	**-**

D1. TEACHING PLAN - 1

Module - 1

Title:	**Introduction to Control Systems**	Appr	10 Hrs

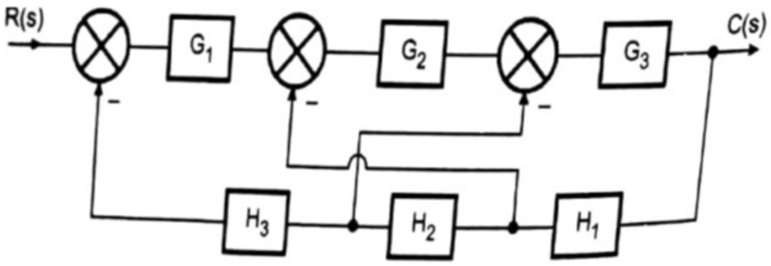
		Time:	
a	***Course Outcome***	**CO**	**Blooms**
	The student should be able to:		
	Apply mathematical modeling to determine the transfer function of a system.		
b	***Course Schedule***	-	-
Class No	**Portion covered per hour**	**-**	**-**
1	Types of Control Systems.	CO1	L2
2	Effect of Feedback Systems.	CO1	L2
3	Differential equation of Physical Systems –Mechanical Systems.	CO1	L2 – L3
4	Differential equation of Physical Systems –Electrical Systems.	CO1	L2 – L3
5	Electromechanical systems.	CO1	L2 – L3
6	Electromechanical systems.	CO1	L2 – L3
7	Electromechanical systems.	CO1	L2 – L3
8	Analogous Systems.	CO1	L2 – L3
9	Analogous Systems.	CO1	L2 – L3
10	Analogous Systems.	CO1	L2 – L3
c	**Application Areas**	**-**	**-**
-	Students should be able employ / apply the Module learnings to . . .	-	-
1	Used in steam generator design	CO1	L2 – L3
2	Used in servomotors	CO1	L2 – L3
d	**Review Questions**		
-			
1	For the mechanical system shown in below Fig. (i)Obtain its mathematical model .(ii)Write the performance equation (iii)Obtain its Force-Voltage and Force-current analogous circuits 	CO1	L2
2	Distinguish closed loop control system from open loop control system with suitable examples.	CO1	L3
3	Obtain the transfer function of the system shown in below Fig. 	CO1	L3
4	Explain linear and non-linear control system.	CO1	L2
5	For the mechanical system shown in Fig.Q1(b): i) Draw the mechanical network. ii) Obtain equations of motion. H.) Draw an electrical network based on force current analogy. 	CO1	L3

6	For the circuit shown in below Fig 'IC' is the gain of an ideal amplifier. Determine the transfer function I(s) / V (s) 	CO1	L3
7	For the circuit shown in below Fig 'IC' is the gain of an ideal amplifier. Determine the transfer function I(s) / V (s) 	CO1	L3
e	**Experiences**	-	-
1		CO1	L2
2			

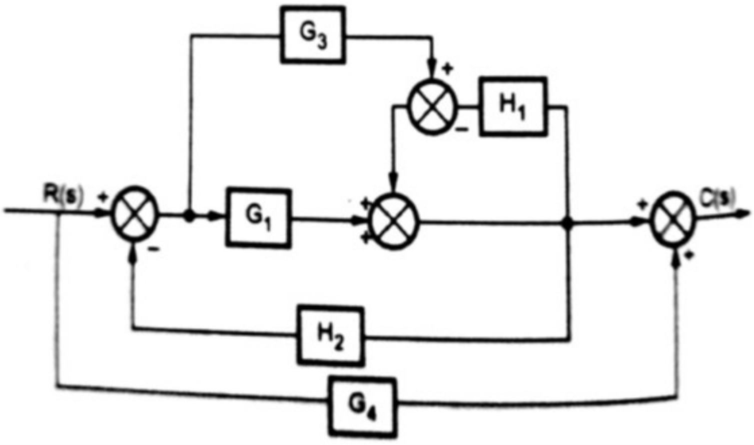
Module – 2

Title:	**Block diagrams and signal flow graphs**	Appr Time:	10 Hrs
a	***Course Outcomes***	**CO**	**Blooms**
-	The students should be able to:	-	**Level**
	Apply block diagram reduction technique and signal flow graph reduction methods to determine the transfer function of a system		
b	***Course Schedule***	-	-
Class No	**Portion covered per hour**	**-**	**-**
11	Transfer functions,	CO2	L2 – L3
12	Block diagram algebra	CO2	L2 – L3
13	Block diagram algebra	CO2	L2 – L3
14	Block diagram algebra	CO2	L2 – L3
15	Block diagram algebra	CO2	L2 – L3
16	Block diagram algebra	CO2	L2 – L3

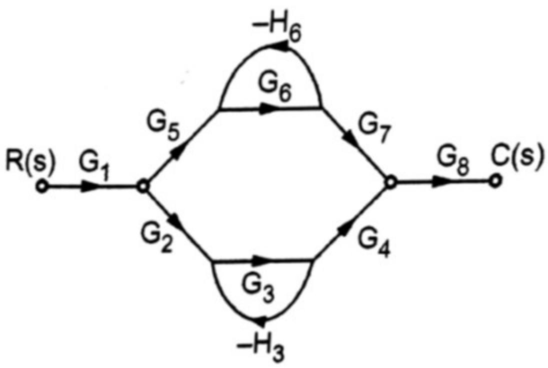
17	Signal Flow graphs.	CO2	L2 – L3
18	Signal Flow graphs.	CO2	L2 – L3
19	Signal Flow graphs.	CO2	L2 – L3
20	Signal Flow graphs.	CO2	L2 – L3
c	**Application Areas**	**-**	**-**
-	Students should be able employ / apply the Module learnings to . . .	-	-
1	Used in single-input single-output filters in the fields of signal processing		
2			
d	**Review Questions**	-	-
-			
1	Apply Block diagram reduction technique to find the transfer function C(S)/ R(s) for the system shown	CO2	L3

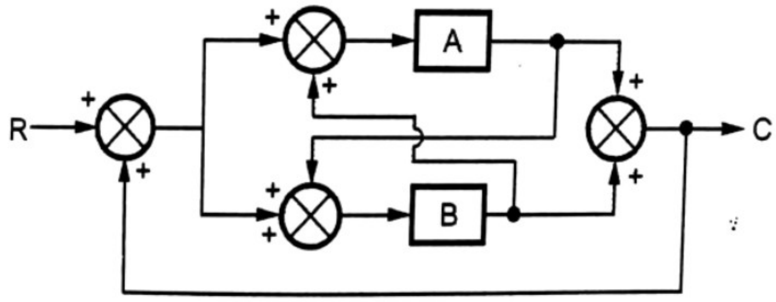
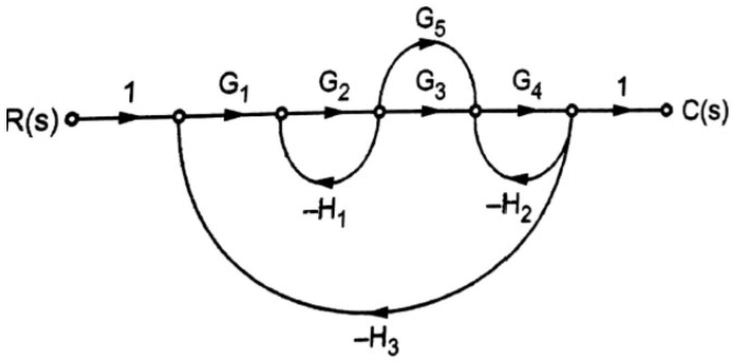
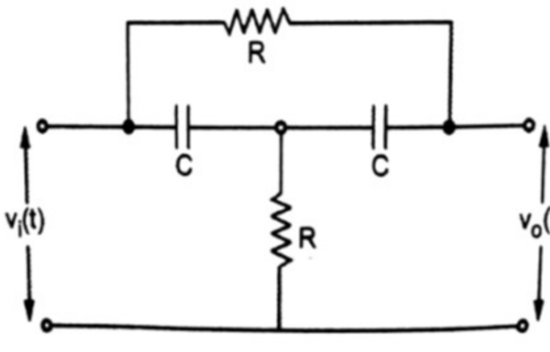
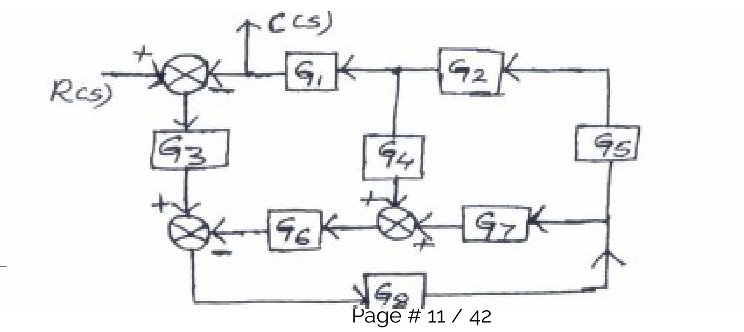


2	Apply Block diagram reduction technique to find the transfer function C(S)/ R(s) for the system shown		



3	Apply Mason's Gain formula to find the transfer function for the signal flow graph shown		



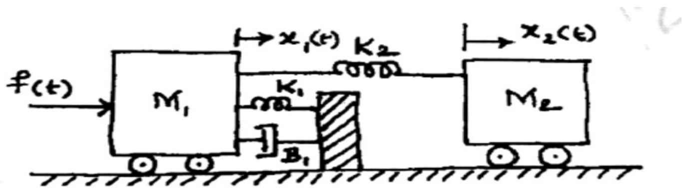
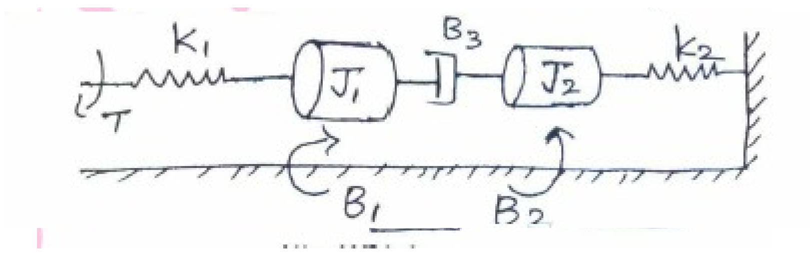
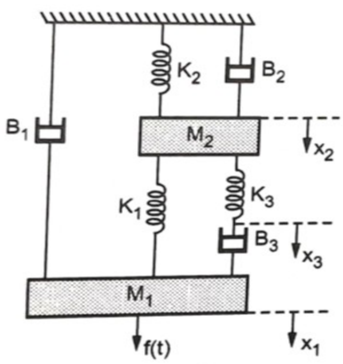
4	Construct the signal flow graph for the block diagram shown Find the transfer function using Mason’s gain formula.  		
5	Construct the block diagram for the signal flow shown in Fig 14 and find the transfer function using block diagram reduction technique. Verify the answer using Mason’s gain formula.  		
6	Construct the signal flow graph for the electrical network shown in Fig and find the transfer function. Also verify the answer using block diagram reduction technique  		
7	Obtain C(s)/R(s) for the block diagram shown in below Fig using block diagram reduction techniques.  		

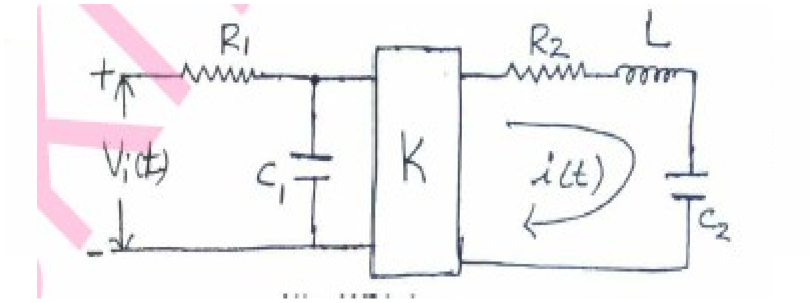
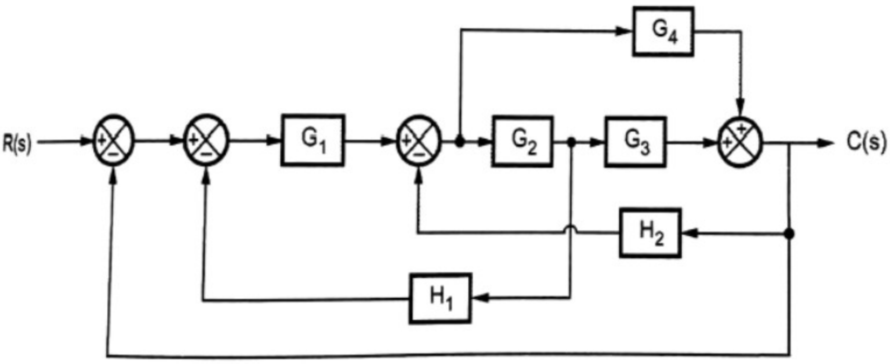
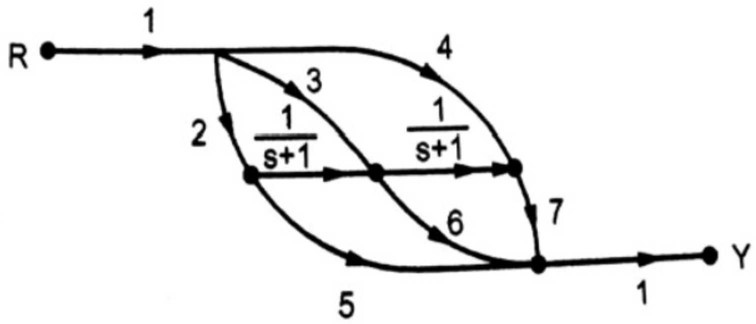
e	**Experiences**	-	-
1		CO3	L2
2			

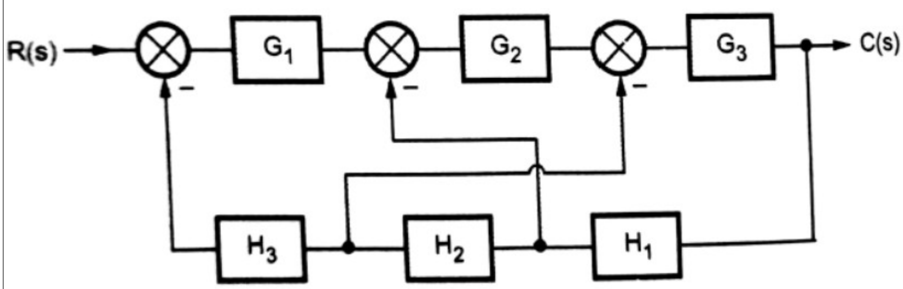
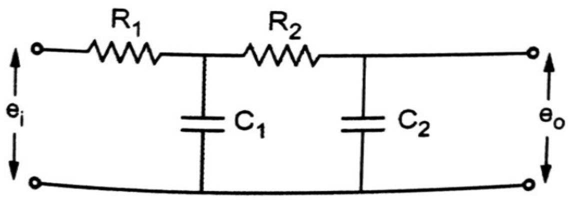
E1. CIA EXAM – 1

a. Model Question Paper - 1

Crs Code:	18EC43	Sem:	4	Marks:	30	Time:	75 minutes
Course:	Control Systems						

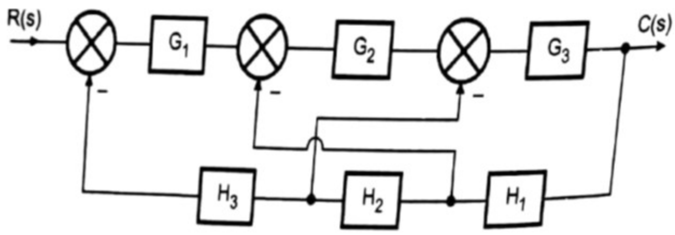
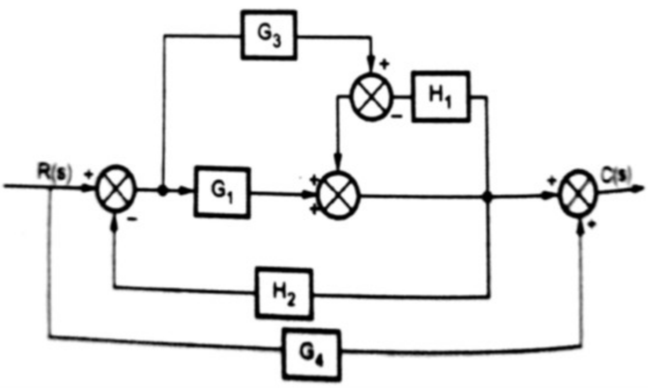
-	-	Note: Answer all questions, each carry equal marks. Module : 1, 2	Marks	CO	Level
		Module 1			
1	a	For the mechanical systems shown below a. Draw the nodal equivalent circuit b. Write the differential equations governing its dynamic behavior. c. Write force voltage and force current analogous electrical networks. d. List all analogous quantities. 	8	CO1	L3
	b	For the circuit shown in below Fig 'IC' is the gain of an ideal amplifier. Determine the transfer function I(s) / V (s) 	7	CO1	L3
		OR			
2	a	For the mechanical systems shown below a. Draw the nodal equivalent circuit b. Write the differential equations governing its dynamic behavior. c. Write force voltage and force current analogous electrical networks. d. List all analogous quantities. 	8	CO1	L3

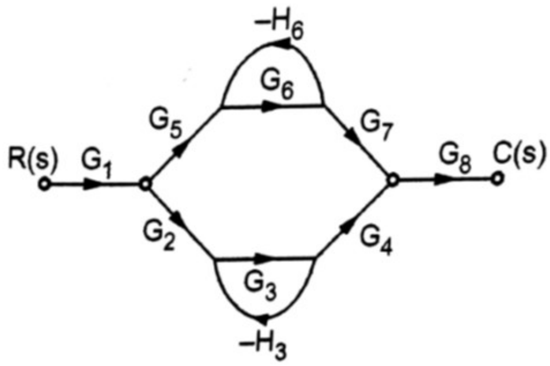
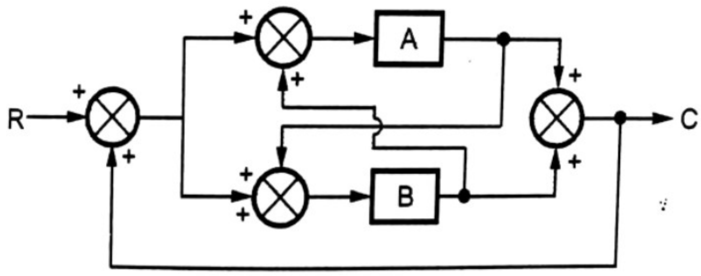
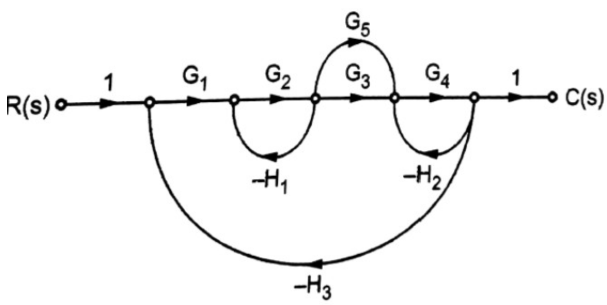
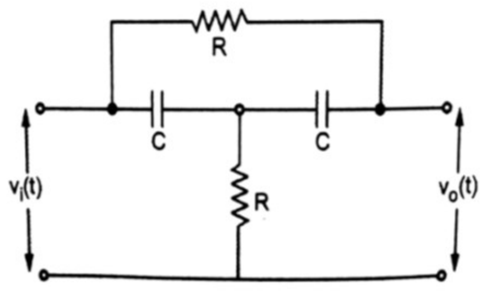
		For the circuit shown in below Fig 'IC' is the gain of an ideal amplifier. Determine the transfer function I(s) / V (s)  	7	CO1	L3
		Module 2			
3		Apply Block diagram reduction technique to find the transfer function C(S)/ R(s) for the system shown  	8	CO2	L3
	b	Apply Mason's Gain formula to find the transfer function for the signal flow graph shown  	7	CO2	L3
		OR			
4	a	Construct the signal flow graph for the block diagram shown. Find the transfer function using Mason's gain formula.	8	CO2	L3

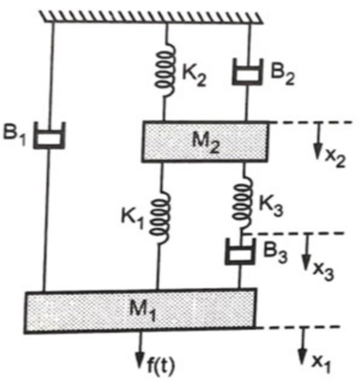
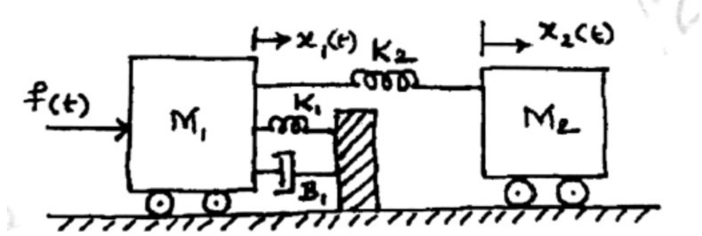
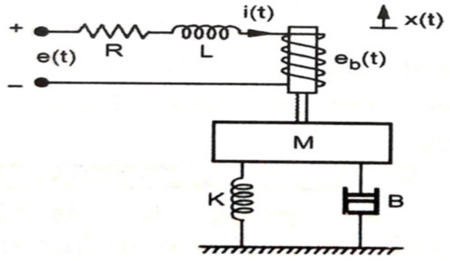
					
	b	Construct the signal flow graph for the electrical network shown and find the transfer function. 	7	CO2	L3

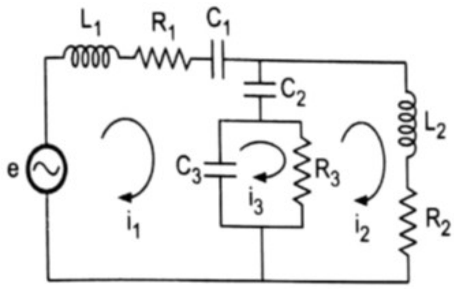
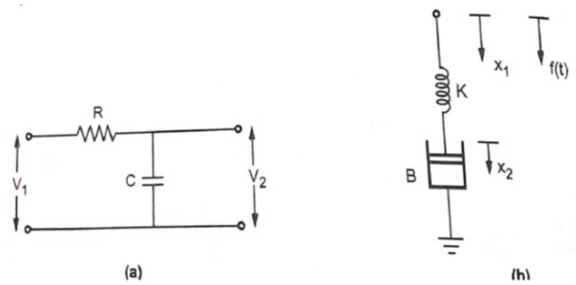
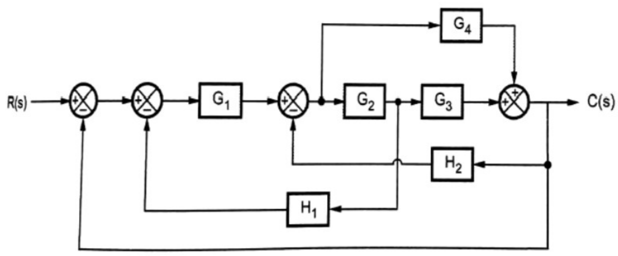
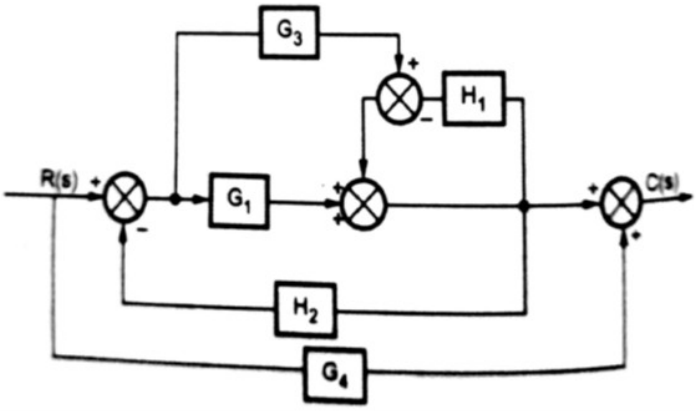
b. Assignment -1

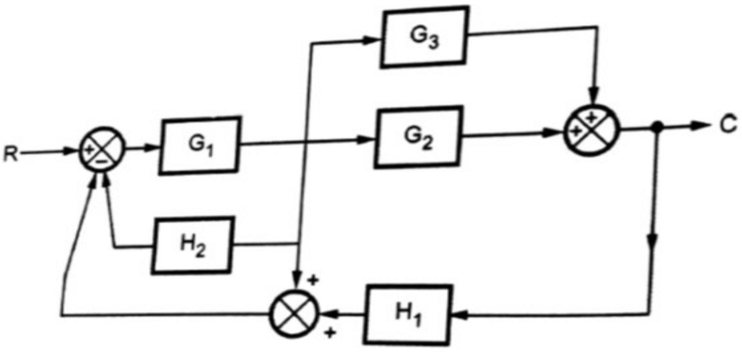
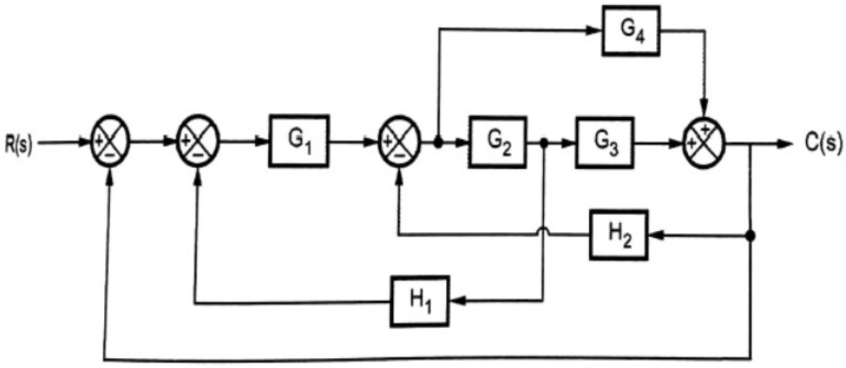
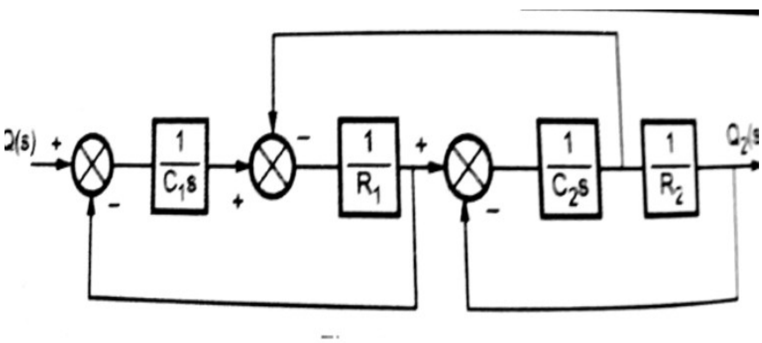
Model Assignment Questions							
Crs Code:	18EC43	Sem:	4	Marks:	10	Time:	90 – 120 minutes
Course:	Control Systems						

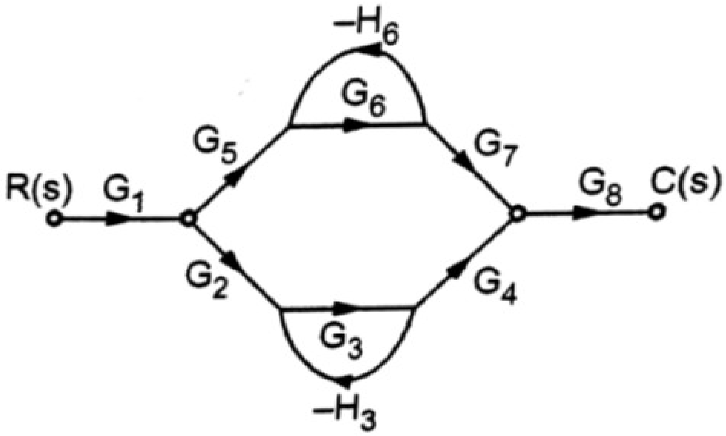
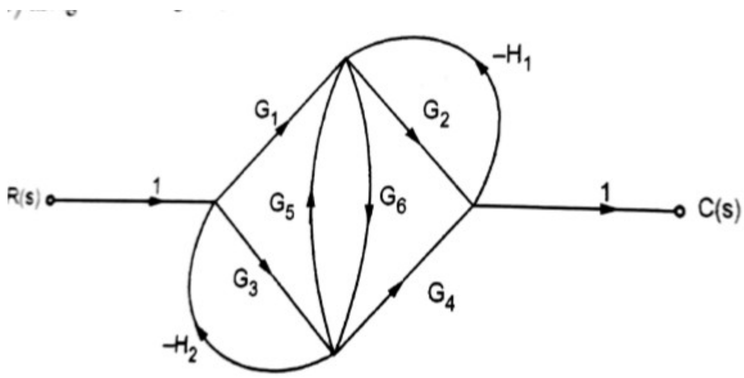
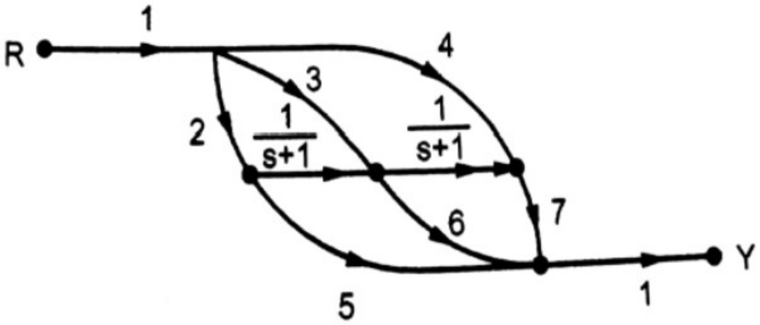
SNo	Assignment Description	Marks	CO	Level
1	Apply Block diagram reduction technique to find the transfer function C(S)/ R(s) for the system shown 	**8**	**CO1**	**L32**
2	Apply Block diagram reduction technique to find the transfer function C(S)/ R(s) for the system shown 	**8**	**CO1**	**L32**

3	Apply Mason's Gain formula to find the transfer function for the signal flow graph shown 	8	CO1	L32
4	Construct the signal flow graph for the block diagram shown Find the transfer function using Mason's gain formula. 	8	CO1	L32
4	Construct the block diagram for the signal flow shown in Fig 14 and find the transfer function using block diagram reduction technique. Verify the answer using Mason's gain formula. 	8	CO1	L32
5	Construct the signal flow graph for the electrical network shown in Fig and find the transfer function. Also verify the answer using block diagram reduction technique 	10	CO1	L3

6	For the mechanical systems shown below a. Draw the nodal equivalent circuit b. Write the differential equations governing its dynamic behavior. c. Write force voltage and force current analogous electrical networks. d. List all analogous quantities.  	**8**	**CO1**	**L3**
7	For the mechanical systems shown below a. Draw the nodal equivalent circuit b. Write the differential equations governing its dynamic behavior. c. Write force voltage and force current analogous electrical networks. d. List all analogous quantities.  	**10**	**CO1**	**L3**
8	Obtain the transfer function X(S)/Ei(S) for the electromechanical system shown below  	**10**	**CO1**	**L3**

	Force voltage analogy of the translational mechanical system is given below. Obtain its analogous mechanical system. Write the performance equation. 			
9	Show that the system shown in Fig(a) and (b) are analogous to each other 	7	CO1	L3
10	Apply Block diagram reduction technique to find the transfer function C(S)/ R(s) for the system shown 	10	CO2	L3
11	Apply Block diagram reduction technique to find the transfer function C(S)/ R(s) for the system shown 	10	CO2	L3

12	Apply Block diagram reduction technique to find the transfer function C(S)/ R(s) for the system shown 	**10**	**CO2**	**L3**
13	Apply Block diagram reduction technique to find the transfer function C(S)/ R(s) for the system shown 	**10**	**CO2**	**L3**
14	Apply Block diagram reduction technique to find the transfer function C(S)/ R(s) for the system shown 	**10**	**CO2**	**L3**
15	Apply Mason's Gain formula to find the transfer function for the signal flow graph shown	**10**	**CO2**	**L3**

				
16	Apply Mason's Gain formula to find the transfer function for the signal flow graph shown 	**10**	**CO2**	**L3**
17	Apply Mason's Gain formula to find the transfer function for the signal flow graph shown 	**10**	**CO2**	**L3**
18	Construct the signal flow graph for the block diagram shown in Fig 1 and Fig 2. Find the transfer function using Mason's gain formula.	**10**	**CO2**	**L3**

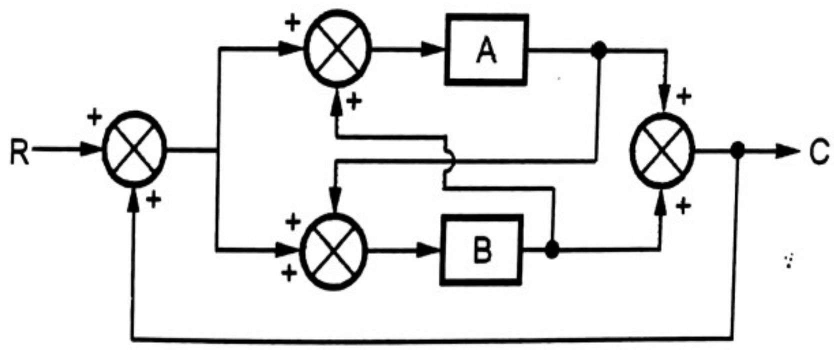


Fig 1

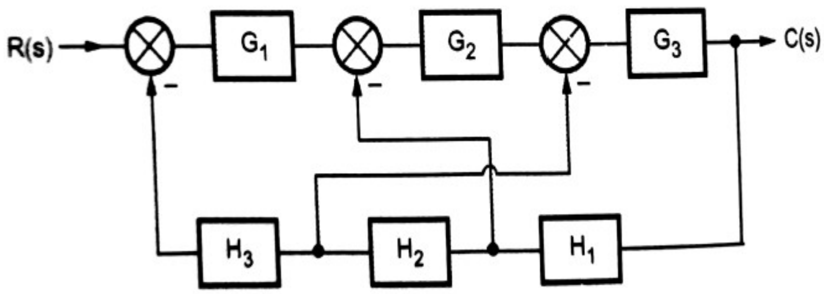
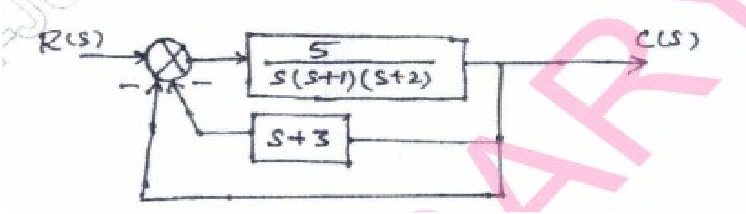
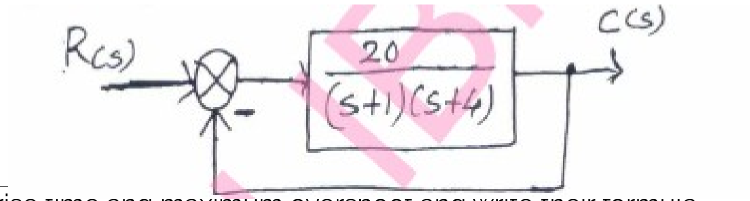


Fig 2

D2. TEACHING PLAN - 2

Module – 3

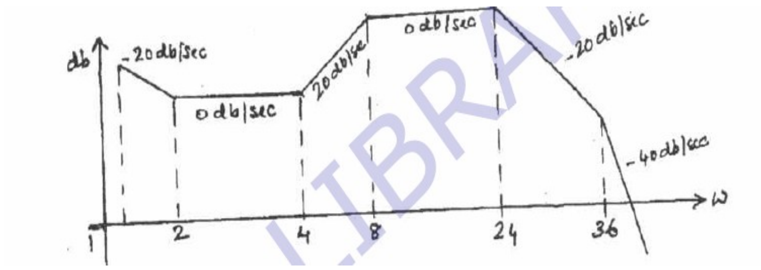
Title:	Time Response of feedback control systems	Appr Time:	10 Hrs
a	***Course Outcomes***	**CO**	**Blooms**
-	At the end of the topic the student should be able to . . .	-	**Level**
	Analyze the behavior of the system in time domain for 1st and 2nd order systems and PID controllers	CO3	L2-L3
b	***Course Schedule***		
Class No	**Portion covered per hour**	**-**	**-**
21.	Standard test signals,	CO3	L2-L3
22.	Unit step response of First and Second order Systems.	CO3	L2-L3
23.	Unit step response of First and Second order Systems.	CO3	L2-L3
24.	Time response specifications, Time response specifications of second order systems,	CO3	L2-L3
25.	Time response specifications of second order systems,	CO3	L2-L3
26.	steady state errors and error constants.	CO3	L2-L3
27.	steady state errors and error constants.	CO3	L2-L3
28.	steady state errors and error constants.	CO3	L2-L3
29.	Introduction to PI, PD and PID Controllers (excluding design).	CO3	L2-L3
30.	Introduction to PI, PD and PID Controllers (excluding design).	CO3	L2-L3
c	**Application Areas**	**-**	**-**
-	Students should be able employ / apply the Module learnings to . . .	-	-
	Practical application to the measurement of phase noise and jitter Used in digital temperature controller		
d	**Review Questions**	-	-
-	The attainment of the module learning assessed through following questions	-	-

1.	For the system shown in Fig. Find the : i) system type ii) static error constants kp, k_v and ka and iii) the steady state error for an input r(t) = 3 + 2t. 	CO3	L3
2.	Find the step-response, C(t) for the system described by C(s) / R(s) = 4/ (S+ 4) Also find the time constant, rise time and settling time.	CO3	L3
3.	Write short notes on PI controller.	CO3	L3
4.	Derive the expression for unit step response for 1^{st} order control system with closed loop transfer function K/(S+1/t)	CO3	L3
5.	Derive the expression for unit step response for 2^{nd} order control system with closed loop transfer function K/(S+1/t)	CO3	L3
6.	Write short notes on PD controller.	CO3	L3
7.	List the standard test inputs used in control system and write their Laplace transform.	CO3	L3
8.	Find Kp, Kv, Ka and steady state error for a system with open loop transfer function as G(s) / H(s) = (10(s + 2)(s + 3)) / (s(s +1)(s + 4)(s + 5)) where the input is r(t) = 3 + t + t^2.	CO3	L3
9.	For the system shown in Fig, obtain closed loop transfer function, damping ratio natural frequency and expression for the output response if subjected to unit step input. 	CO3	L3
10.	Define rise time and maximum overshoot and write their formula.	CO3	L3
11.	For a given system G(s) / H(s) = 2 K / (s (s + 2)(s + 3)). Find the value of K to limit steady state error to 10 when input to system is 1+10t + $20t^2$.	CO3	L3
12.	For a unity feedback control system with G(s) = 64/ (s(s + 9.6)) Write the output response to a unit step input. Determine: i) The response at t = 0.1 sec. ii) Settling time for ± 2% of steady state.	CO3	L3
13.	A control system with open loop transfer function K(S+2)/(S^2+10S+20) produces 20% steady state error with unit step input. Determine the value of constant K.	CO3	L3
14.	Derive the expression for unit step response for 1^{st} order control system with closed loop transfer function K/(S+1/t)	CO3	L3
15.	Derive the expression for unit step response for 2^{nd} order control system with closed loop transfer function K/(S+1/t)	CO3	L3
e	**Experiences**	-	-
1			
2			

Module – 4

Title:	**Stability analysis**	Appr Time:	10 Hrs
a	***Course Outcomes***	**CO**	**Blooms**

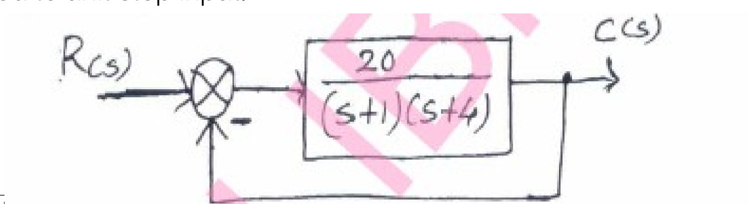
-	At the end of the topic the student should be able to . . .	-	**Level**
	Analyze the stability of the system using various time domain and bode plot techniques	CO4	L2-L3
b	***Course Schedule***		
Class No	**Portion covered per hour**	**-**	**-**
31.	Concepts of stability.	CO4	L2-L3
32.	Necessary conditions for Stability, Routh stability criterion,	CO4	L2-L3
33.	Relative stability analysis: more on the Routh stability criterion.	CO4	L2-L3
34.	Introduction to Root-Locus Techniques,	CO4	L2-L3
35.	The root locus concepts.	CO4	L2-L3
36.	Construction of root loci.	CO4	L2-L3
37.	Construction of root loci.	CO4	L2-L3
38.	**Frequency domain analysis and stability:** Correlation between time and frequency response, Bode Plots,	CO4	L2-L3
39.	Bode Plots,	CO4	L2-L3
40.	Experimental determination of transfer function.	CO4	L2-L3
c	**Application Areas**	**-**	**-**
-	Students should be able employ / apply the Module learnings to . . .	-	-
	Used in linear time-invariant systems.		
	Used to design the damping ratio and natural frequency of a feedback system.		
	The plot can be used to interpret how the input affects the output in both magnitude and phase over frequency.		
d	**Review Questions**	-	-
-	The attainment of the module learning assessed through following questions	-	-
1.	Determine the ranges of K such that the characteristic equation : $S^3 + 3(K + 1)S^2 + (7K + 5)S + (4K + 7) = 0$, has roots more negative than S = -1.	CO4	L2-L3
2.	Find the range of K for which the system with closed loop transfer function K / (S(S+2)(S^2+ S+1)) is stable. For what value of K the system oscillates and what is the corresponding frequency of oscillation.	CO4	L2-L3
3.	The open loop transfer function of a feedback control system is given by K/(S(S+2)(S+1)). Construct the root locus and find the range of K for which the closed loop system is stable. .	CO4	L2-L3
4.	Check the;&ability of the given characteristic equation using Routh's method.$S^6 + 2S^5 + 8S^4 + 12S^3 + 20S^2 + 16S + 16 = 0$.	CO4	L2-L3
5.	Mention few limitations of Routh's criterion	CO4	L2-L3
6.	Construct the root locus of a control system with characteristic equation (S2+2S+2) + K(S+4)=0. Determine the stability of the closed loop system. Show that a part of root locus is a circle of radius √10 units with centre at (-4, 0).	CO4	L2-L3
7.	Sketch the complete root locus of system having, G (s) = K / (**S(S +1)(S** + 2)(S + 3))	CO4	L2-L3
8.	Consider the system with G(S)H(s) = . K / (S (S -1)(S+ 4)) Find whether S = —2 point is on root locus or not using angle condition.	CO4	L2-L3
9.	Sketch the root locus plot for a negative feedback control system whose open loop transfer function is given by G(s)H(s) = K / (s(s +3)(s^2 + 2s + 2)) for all values of K ranging from 0 to infinity. Also find the value of K for a damping ratio of 0.5	CO4	L2-L3
10.	Sketch the rough nature of the root locus of a certain control system whose C.E is given by $s^3 + 9s^2 + Ks + K = 0$, comment on the stability.	CO4	L2-L3
11.	Explain Rouths-Harwitz stability criterion.	CO4	L2-L3
12.	$s^6 + 4s^5 + 3s^4 — 16s^2 — 64s — 48 = 0$. Find the number of roots of this equation real	CO4	L2-L3

	part, zero real part and negative real part using RH criterion.		
13.	The open loop transfer function of a system is G(s) = K/ (s (1+ s)(1+ 0.1s)) Determine the values of K such that (i) gain margin = 10 dB ii) phase margin = 24°. Use Bode plot.	CO4	L2-L3
14.	Derive the expression for resonant peak 'Mr' and corresponding resonant frequency `Wr' for a second—order under-damped system in frequency response analysis.	CO4	L2-L3
15.	For a closed loop control system G(s) = 100 / (s (s+8), H(s) = 1. Determine the resonant peak and resonant frequency.	CO4	L2-L3
16.	Explain lag-lead compensator network and briefly discuss the effects of lead-lag compensator.	CO4	L2-L3
17.	For a unity feedback system G(s) = 242((s+5))/ (s(s +1)(s^2+ 5s +121)) Sketch the bode plot and find gain crossover freq,phase crossover freq, gain margin and phase margin.	CO4	L2-L3
18.	Construct the Bode plot for the system with open loop transfer function $\frac{K}{S(S+1)(1+0.1S)}$ Determine the value of K such that (a) gain margin = 10db (b) Phase margin = 50^0.	CO4	L2-L3
19.	Determine the transfer function of a system whose asymptotic Bode plot is as shown in fig 	CO4	L2-L3
e	**Experiences**	-	-
1			
2			

E2. CIA EXAM – 2

a. Model Question Paper - 2

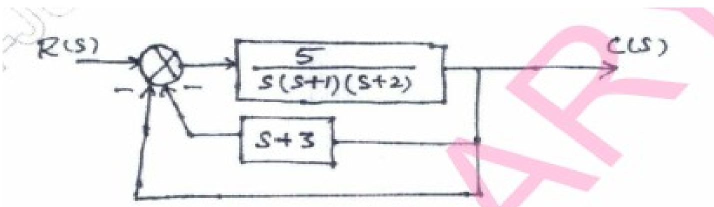
Crs Code:	18EC43	Sem:	4	Marks:	30	Time:	75 minutes
Course:	Control Systems						

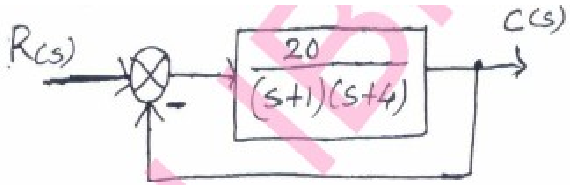
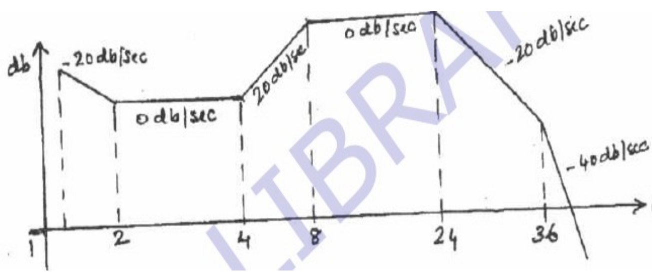
-	-	Note: Answer all questions, each carry equal marks. Module : 3, 4	Marks	CO	Level
		MODULE 1			
1	a	For the system shown in Fig, obtain closed loop transfer function, damping ratio natural frequency and expression for the output response if subjected to unit step input. 	7	CO3	L3
	b	Derive the expression for unit step response for 2^{nd} order control system with closed loop transfer function K/(S+1/t)	8	CO3	L3
		OR			

2	a	Find Kp, Kv, Ka and steady state error for a system with open loop transfer function as G(s) / H(s) = (10(s + 2)(s + 3)) / (s(s +1)(s + 4)(s + 5)) where the input is r(t) = 3 + t + t^2.	7	CO3	L3
	b	Write short notes on PI and PD controller.	8	CO3	L3
		MODULE 2			
3	a	Find the range of K for which the system with closed loop transfer function K / (S(S+2)(S^2+ S+1)) is stable. For what value of K the system oscillates and what is the corresponding frequency of oscillation.	7	CO4	L3
	b	Construct the root locus of a control system with characteristic equation (S2+2S+2) + K(S+4)=0. Determine the stability of the closed loop system. Show that a part of root locus is a circle of radius √10 units with centre at (-4, 0).	8	CO4	L3
		OR			
4	a	For a unity feedback system G(s) = 242((s+5))/ (s(s +1)(s^2 + 5s +121)) Sketch the bode plot and find gain crossover freq,phase crossover freq, gain margin and phase margin.	10	CO4	L3
	b	Derive the expression for resonant peak 'Mr' and corresponding resonant frequency `Wr' for a second—order under-damped system in frequency response analysis.	5	CO4	L3

b. Assignment – 2

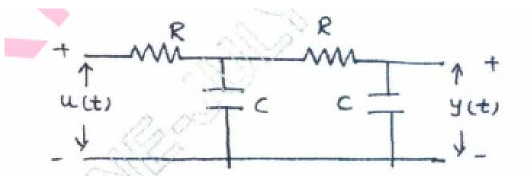
Model Assignment Questions							
Crs Code:	18EC43	Sem:	4	Marks:	10	Time:	90 – 120 minutes
Course:	Control Systems						

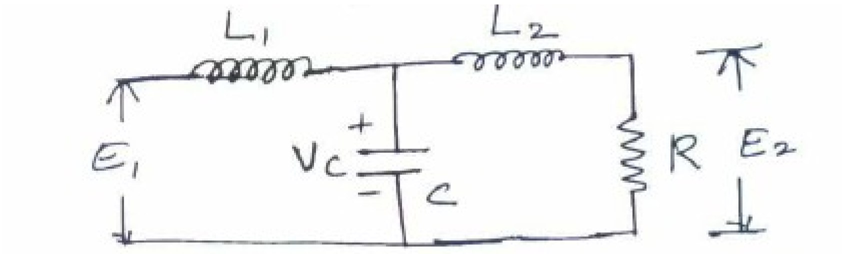
SNo	Assignment Description	Marks	CO	Level
1.	For the system shown in Fig. Find the : i) system type ii) static error constants kp, k_v and ka and iii) the steady state error for an input r(t) = 3 + 2t. 	**10**	**CO3**	**L3**
2.	Find the step-response, C(t) for the system described by C(s) / R(s) = 4/ (S+ 4) Also find the time constant, rise time and settling time.	**10**	**CO3**	**L3**
3.	Write short notes on PI controller.	**10**	**CO3**	**L3**
4.	Derive the expression for unit step response for 1^{st} order control system with closed loop transfer function K/(S+1/t)	**10**	**CO3**	**L3**
5.	Derive the expression for unit step response for 2^{nd} order control system with closed loop transfer function K/(S+1/t)	**10**	**CO3**	**L3**
6.	Write short notes on PD controller.	**10**	**CO3**	**L3**
7.	List the standard test inputs used in control system and write their Laplace transform.	**10**	**CO3**	**L3**
8.	Find Kp, Kv, Ka and steady state error for a system with open loop transfer function as G(s) / H(s) = (10(s + 2)(s + 3)) / (s(s +1)(s + 4)(s + 5)) where the input is r(t) = 3 + t + t^2.	**10**	**CO3**	**L3**
9.	For the system shown in Fig, obtain closed loop transfer function, damping ratio natural frequency and expression for the output response if	**10**	**CO3**	**L3**

	subjected to unit step input. 			
10.	Define rise time and maximum overshoot and write their formula.	**10**	**CO3**	**L3**
11.	For a given system G(s) / H(s) = 2 K / (s (s + 2)(s + 3)). Find the value of K to limit steady state error to 10 when input to system is $1+10t + 20t^2$.	**10**	**CO3**	**L3**
12.	For a unity feedback control system with G(s) = 64/ (s(s + 9.6)) Write the output response to a unit step input. Determine: i) The response at t = 0.1 sec. ii) Settling time for ± 2% of steady state.	**10**	**CO3**	**L3**
13.	A control system with open loop transfer function $K(S+2)/(S^2+10S+20)$ produces 20% steady state error with unit step input. Determine the value of constant K.	**10**	**CO3**	**L3**
14.	Derive the expression for unit step response for 1st order control system with closed loop transfer function K/(S+1/t)	**10**	**CO3**	**L3**
15.	Derive the expression for unit step response for 2nd order control system with closed loop transfer function K/(S+1/t)	**10**	**CO3**	**L3**
16.	Sketch the root locus plot for a negative feedback control system whose open loop transfer function is given by $G(s)H(s) = K / (s(s+3)(s^2 + 2s + 2))$ for all values of K ranging from 0 to infinity. Also find the value of K for a damping ratio of 0.5	**10**	**CO4**	**L4**
17.	Sketch the rough nature of the root locus of a certain control system whose C.E is given by $s^3 + 9s^2 + Ks + K = 0$, comment on the stability.	**10**	**CO4**	**L4**
18.	Explain Rouths-Harwitz stability criterion.	**10**	**CO4**	**L4**
19.	$s^6 + 4s^5 + 3s^4 - 16s^2 - 64s - 48 = 0$. Find the number of roots of this equation real part, zero real part and negative real part using RH criterion.	**10**	**CO4**	**L4**
20.	The open loop transfer function of a system is G(s) = K/ (s (1+ s)(1+ 0.1s)) Determine the values of K such that (i) gain margin = 10 dB ii) phase margin = 24°. Use Bode plot.	**10**	**CO4**	**L4**
21.	Derive the expression for resonant peak 'Mr' and corresponding resonant frequency `Wr' for a second—order under-damped system in frequency response analysis.	**10**	**CO4**	**L4**
22.	For a closed loop control system G(s) = 100 / (s (s+8), H(s) = 1. Determine the resonant peak and resonant frequency.	**10**	**CO4**	**L4**
23.	Explain lag-lead compensator network and briefly discuss the effects of lead-lag compensator.	**10**	**CO4**	**L4**
24.	For a unity feedback system $G(s) = 242((s+5))/(s(s+1)(s^2 + 5s + 121))$ Sketch the bode plot and find gain crossover freq,phase crossover freq, gain margin and phase margin.	**10**	**CO4**	**L4**
25.	Construct the Bode plot for the system with open loop transfer function $\frac{K}{S(S+1)(1+0.1S)}$ Determine the value of K such that (a) gain margin = 10db (b) Phase margin = 50^0.	**10**	**CO4**	**L4**
26.	Determine the transfer function of a system whose asymptotic Bode plot is as shown in fig 	**10**	**CO4**	**L4**

D3. TEACHING PLAN - 3

Module – 5

Title:	Loop and Horn Antenna and Antenna Types	Appr Time:	10 Hrs
a	***Course Outcomes***	**CO**	**Blooms**
-	At the end of the topic the student should be able to . . .	-	**Level**
	Analyze the stability of the system using frequency domain techniques and Analyze the electrical system using state variable technique.	CO5	L3-L4
b	***Course Schedule***	-	-
Class No	**Portion covered per hour**	**-**	**-**
41.	Introduction to Polar Plots, (Inverse Polar Plots excluded)	CO5	L3-L4
42.	Mathematical preliminaries, Nyquist Stability criterion, (System s with transportation lag excluded)	CO5	L3-L4
43.	Nyquist Stability criterion	CO5	L3-L4
44.	Nyquist Stability criterion	CO5	L3-L4
45.	Introduction to lead, lag and lead- lag compensating networks (excluding design).	CO5	L3-L4
46.	**Introduction to State variable analysis:** Concepts of state, state variable and state models for electrical systems.	CO5	L3-L4
47.	State models for electrical systems.	CO5	L3-L4
48.	State models for electrical systems.	CO5	L3-L4
49.	Solution of state equations.	CO5	L3-L4
50.	Solution of state equations.	CO5	L3-L4
c	**Application Areas**	**-**	**-**
-	Students should be able employ / apply the Module learnings to . . .	-	-
	Used in Design of model based controllers such as MPC,		
d	**Review Questions**	-	-
-	The attainment of the module learning assessed through following questions	-	-
	Find the state-tarannsition matrix for $A = \begin{bmatrix} 0 & -1 \\ +2 & -3 \end{bmatrix}$.	CO5	L3
	Obtain an appropriate state model for a system re mented by an electric circuit as shown in below Fig. 	CO5	L3
	linear time invariant system is characterized by the homogeneous state equation $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$	CO5	L3

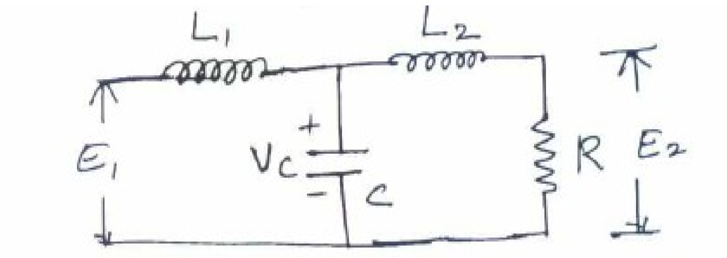
	Compute the solution of homogeneous equation, assume the initial state vector. $X_0 = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$.		
	State the properties of state transition matrix.	CO5	L3
	Find the transfer function of the system having state model. $\dot{X} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$ and $y = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$	CO5	L3
	Obtain the state model for the system represented by the differential equation $\frac{d^3y(t)}{dt^3} + 6\frac{d^2y(t)}{dt^2} + 11\frac{dy(t)}{dt} + 10y(t) = 3u(t)$.	CO5	L3
	Obtain the state model of given electrical network shown in Fig. 	CO5	L3
	Find the state transition matrix for $A = \begin{bmatrix} 0 & -1 \\ 2 & -3 \end{bmatrix}$.	CO5	L3
	single input single output system has the state and output equations i) Determine its transfer function (ii) Find its state transition matrix. $\dot{x} = \begin{bmatrix} 0 & 1 \\ -6 & -5 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} r$ $y = \begin{bmatrix} 5 & 0 \end{bmatrix} x$	CO5	L3
	Draw polar plot of G(s)H(s) = 100/ (s^2 +10S+100)	CO5	L3
	Draw the polar plot for the following open-loop transfer function G(S)H(s) = 1/ (1+ 0.1s)	CO5	L3
	Sketch the Nyquist plot for a system with the open-loop transfer function : G(s)H(s) = (k (1+ 0.5s)(1 + s)) / ((1 + 10s)(s —1)) . Determine the range of values of 'K' for which the system is stable.	CO5	L3
	Explain Nyquist stability criteria	CO5	L3
	Using Nyquist stability criterion, find the closed loop stability of a negative feedback	CO5	L3

	control system whose open-loop transfer function is given by G(s)H(s) = 5 /(s(s —1))		
e	**Experiences**	-	-
1		CO10	L2
2		CO9	

E3. CIA EXAM – 3

a. Model Question Paper - 3

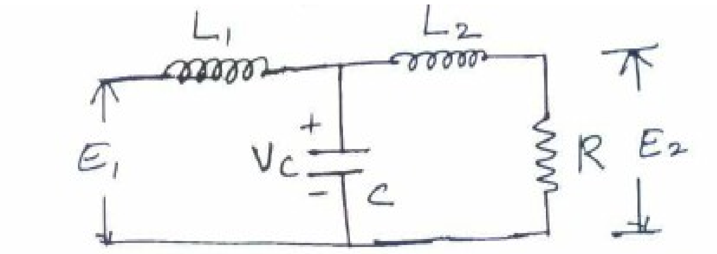
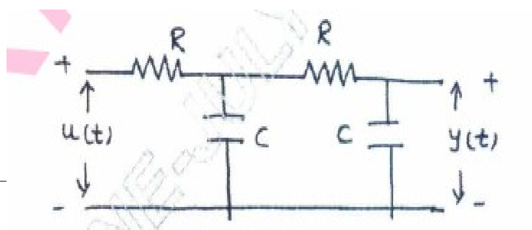
Crs Code	18EC43	Sem:	4	Marks:	30	Time:	75 minutes
Course:	Control Systems						

-	-	Note: Answer all questions, each carry equal marks. Module : 5	Marks	CO	Level
1	a	Obtain the state model of given electrical network shown in Fig.  	7	CO5	L3
	b	Find the state-tarannsition matrix for $A = \begin{bmatrix} 0 & -1 \\ +2 & -3 \end{bmatrix}$.	8	CO5	L3
		OR			
2	a	Draw the polar plot for the following open-loop transfer function G(S)H(s) = 1/ (1+ 0.1s)	7	CO5	L3
	b	Sketch the Nyquist plot for a system with the open-loop transfer function : G(s)H(s) = (k (1+ 0.5s)(1 + s)) / ((1 + 10s)(s —1)) . Determine the range of values of 'K' for which the system is stable.	8	CO5	L3
		MODULE-2	**15**		
3	a	Find the transfer function of the system having state model. $\dot{X} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$ and $y = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$	7	CO5	L2
	b	Obtain the state model for the system represented by the differential equation $\frac{d^3y(t)}{dt^3} + 6\frac{d^2y(t)}{dt^2} + 11\frac{dy(t)}{dt} + 10y(t) = 3u(t)$.	8	CO5	L3
		OR			
4	a	State the properties of state transition matrix.	6	CO5	L2
	b	single input single output system has the state and output equations	9	CO5	L3

		$\dot{x} = \begin{bmatrix} 0 & 1 \\ -6 & -5 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} r$ $y = [5 \quad 0] x$ i) Determine its transfer function (ii) Find its state transition matrix.			

b. Assignment – 3

Model Assignment Questions							
Crs Code:	18EC43	Sem:	4	Marks:	10	Time:	90 – 120 minutes
Course:	Control Systems						

SNo	Assignment Description	Marks	CO	Level
1.	Obtain the state model of given electrical network shown in Fig. 	7	CO5	L3
2.	Find the state-tarannsition matrix for $A = \begin{bmatrix} 0 & -1 \\ +2 & -3 \end{bmatrix}.$	8	CO5	L3
3.	linear time invariant system is characterized by the homogeneous state equation $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$ Compute the solution of homogeneous equation, assume the initial state vector. $X_0 = \begin{bmatrix} 1 \\ 0 \end{bmatrix}.$	7	CO5	L3
4.	Obtain an appropriate state model for a system re mented by an electric circuit as shown in below Fig. 	8	CO5	L3

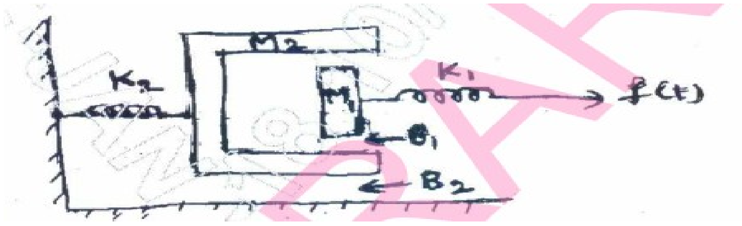
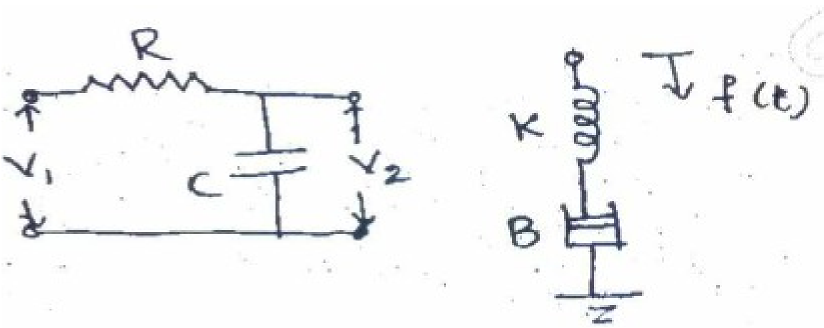
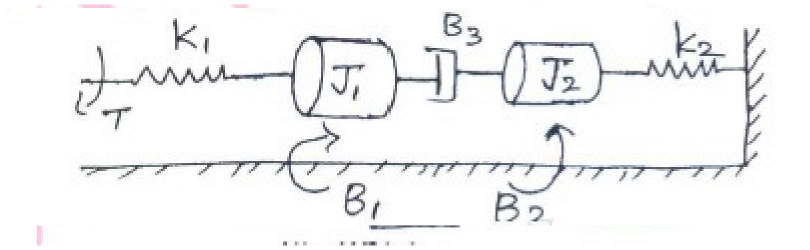
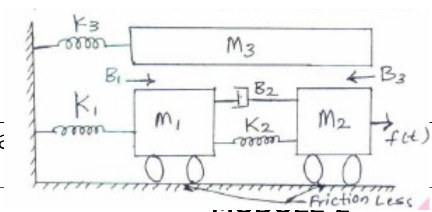
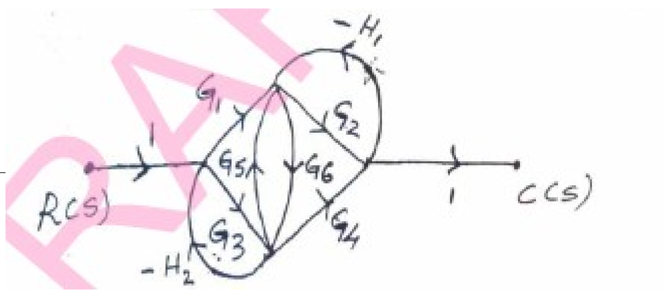
5.	Find the transfer function of the system having state model. $$\dot{X} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u \quad \text{and} \quad y = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$	7	CO5	L3
6.	Obtain the state model for the system represented by the differential equation $$\frac{d^3y(t)}{dt^3} + 6\frac{d^2y(t)}{dt^2} + 11\frac{dy(t)}{dt} + 10y(t) = 3u(t).$$	8	CO5	L3
7.	State the properties of state transition matrix.	7	CO5	L2
8.	single input single output system has the state and output equations $$\dot{x} = \begin{bmatrix} 0 & 1 \\ -6 & -5 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} r$$ $$y = \begin{bmatrix} 5 & 0 \end{bmatrix} x$$ i) Determine its transfer function (ii) Find its state transition matrix.	8	CO5	L3
9.	Draw polar plot of G(s)H(s) = 100/ (s^2 +10S+100)	**10**	CO5	L3
10.	Draw the polar plot for the following open-loop transfer function G(S)H(s) = 1/ (1+ 0.1s)	**10**	CO5	L3
11.	Sketch the Nyquist plot for a system with the open-loop transfer function : G(s)H(s) = (k (1+ 0.5s)(1 + s)) / ((1 + 10s)(s —1)) . Determine the range of values of 'K' for which the system is stable.	**10**	CO5	L3
12.	Explain Nyquist stability criteria	**10**	CO5	L3
13.	Using Nyquist stability criterion, find the closed loop stability of a negative feedback control system whose open-loop transfer function is given by G(s)H(s) = 5 /(s(s —1))	**10**	CO5	L3

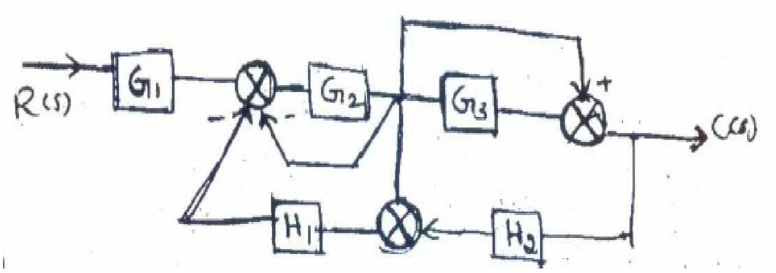
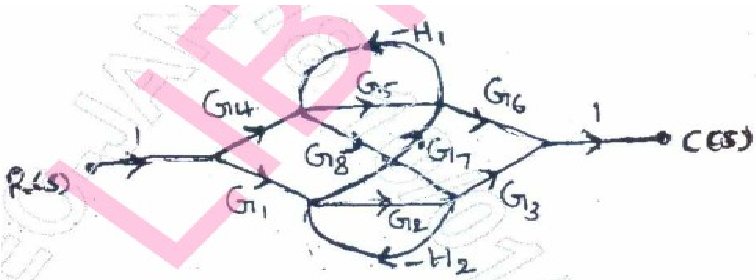
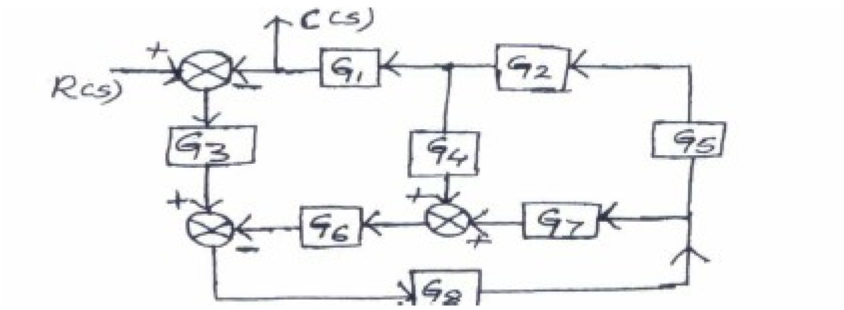
F. EXAM PREPARATION

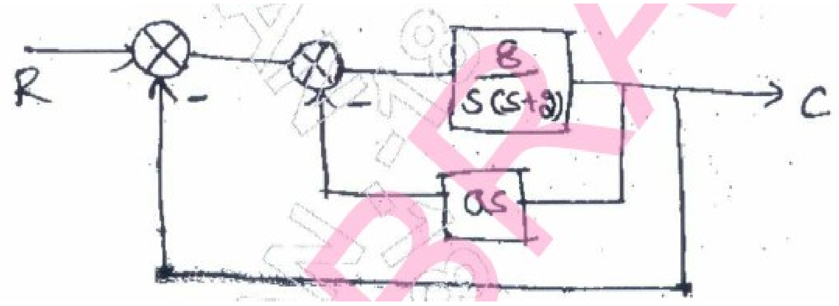
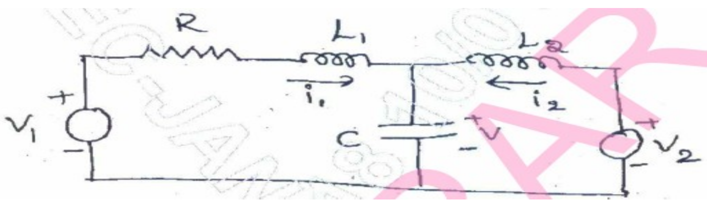
1. University Model Question Paper

Course:	Control Systems					Month / Year	June/2020
Crs Code:	18EC43	Sem:	4	Marks:	100	Time:	180 minutes

Mod ule		Answer all FIVE full questions. All questions carry equal marks.	**Marks**	**CO**	**Level**
1	a	Define control system. Distinguish between open loop and closed loop systems with examples.	6	CO1	L3
	b	Write the differential equations for the mechanical system shown in Fig. and obtain F-V and F-1 analogous electrical networks.	7	CO1	L3

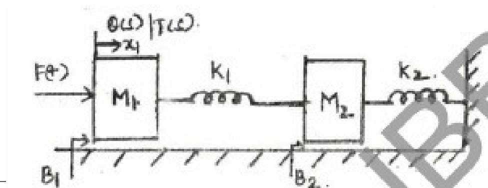
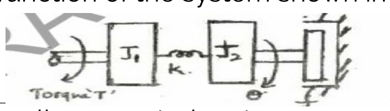
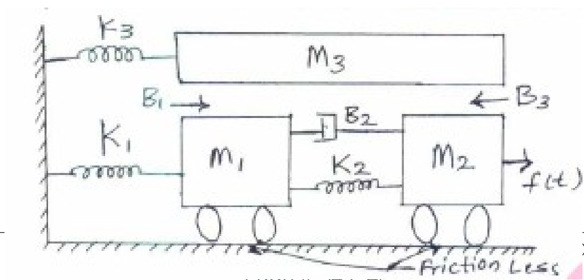
					
	c	Show that two systems shown in Fig.Q2(a) are analogous systems, by comparing their functions. 	7	CO1	L3
		OR			
	a	For the circuit shown in below Fig 'IC' is the gain of an ideal amplifier. Determine the transfer function I(s) / V (s) 	8	CO1	L3
	b	For the mechanical system shown in Fig.Q1(b): i) Draw the mechanical network. ii) Obtain equations of motion. H.) Draw an electrical network based on force current analogy. 	8		
	c	Explain linear a	4		
		MODULE 2			
2	a	Using Mason's gain formula, find the gain of the system shown in Fig. 	8	CO2	L3

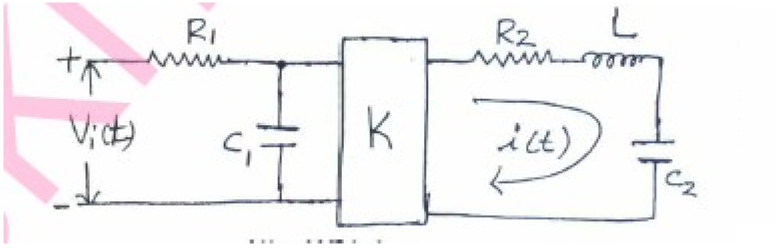
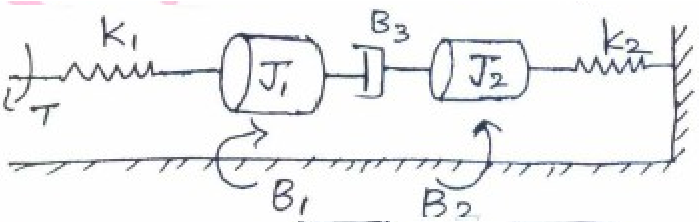
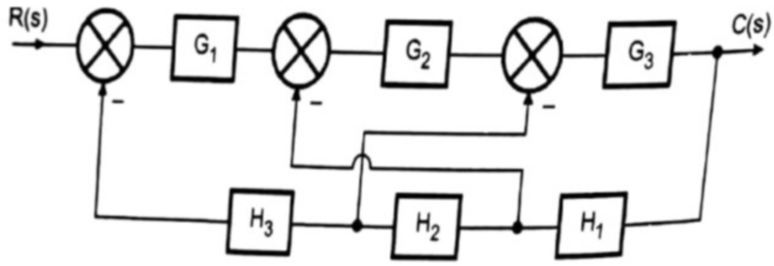
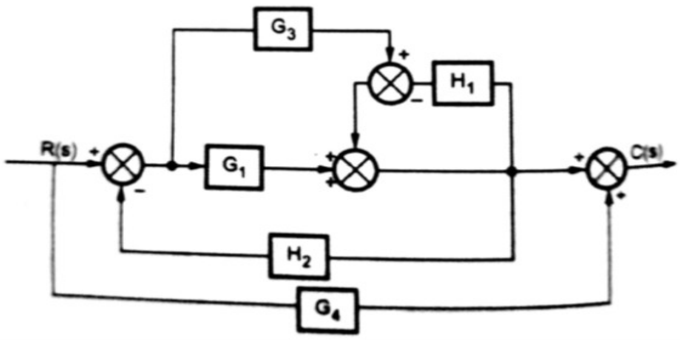
	b	Define the follwing terms with respect SFG (i) Input node (ii) output node (iii) loop (iv) forward path	4	CO2	L2
	c	Reduce the block diagram shown in Fig.Q2(c) using reduction rules and obtain C(s)/R(s). 	8	CO2	L3
		OR			
	a	Using Mason's gain formula, find the gain of the system shown in Fig. 	10		
	b	Obtain C(s)/R(s) for the block diagram shown in below Fig using block diagram reduction techniques. 	10		
		MODULE-3			
3	a	Obtain an expression for time response of the first order system subjected to unit step input.	6	CO3	L3
	b	Explain proportional + integral + differential controller and their effect on stability.	7	CO3	L3
	c	A unity feedback system is characterized by an open loop transfer function	7	CO3	L3

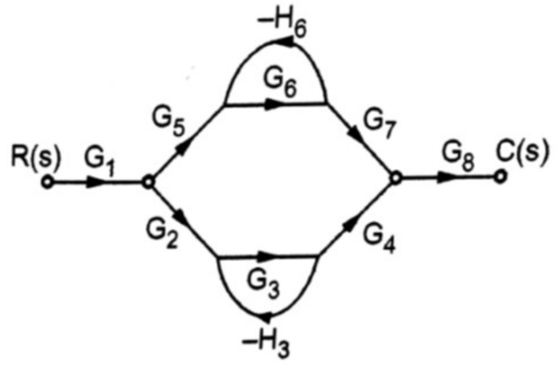
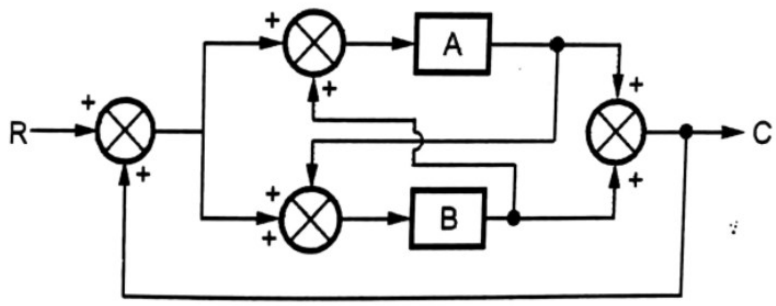
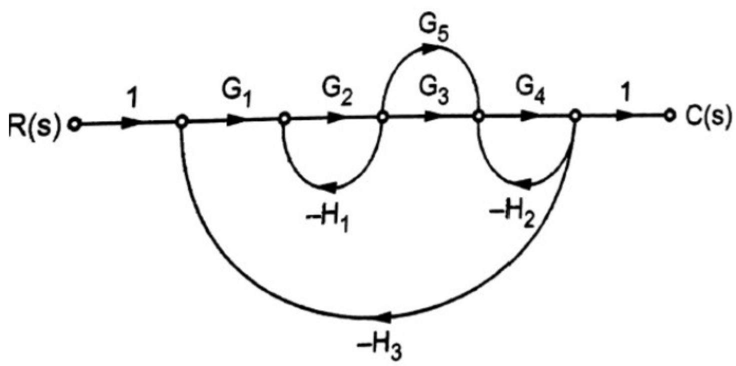
		G(s) = K/ (s(s +10)). Determine the gain K so that system will have a damping ratio of 0.5. For this value of K,find settling time (2% criterion), peak overshoot and time to peak overshoot for a unit step input.			
		OR		CO	L
	a	With a neat sketch explain all the time domain specifications.	12	CO4	L3
	b	For the system shown in Fig. Determine the value of 'a' which gives damping factor 0.7. What is the steady state error to unit ramp input for value of 'a'. 	8	CO4	L3
		MODULE-4			
4	a	The open loop transfer function of a system is G(s) = K / (s(1 + 0.5s)(1 + 0.2s)) using Bode plot. Find K so that : i) Gain margin is 6dB ii) Phase margin is 25°.	10	CO4	L3
	b	List the advantages of Root Locus method.	3	CO4	L2
	c	Using RH criterion determine the stability of the system having the characteristic equation $s^6 + 2s^5 + 5s^4 + 8s^3 + 8s^2 + 8s + 4 = 0$.	7	CO4	L2
		OR			
	a	The open loop transfer function of a control system is given by $$G(s) = \frac{k}{s(s+2)(s^2+6s+2s)}.$$ Sketch the complete root locus as k is varied from zero to infinity.	10	CO4	L2
	b	The open loop transfer function of a control system is G(s)H(s) = 1/ (s^2+s+2) . Sketch the Bode plot and analyze the gain margin and phase margin.	10	CO4	L3
		MODULE-5			
5	a	Find the transfer function of the system having state model. $$\dot{X} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix}u \quad \text{and} \quad y = \begin{bmatrix} 1 & 0 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$	10	CO5	L3
	b	Consider the circuit of Fig. Identify suitable state variables and write its state vector matrix equation. Note that there are two inputs. 	10	CO10	L3

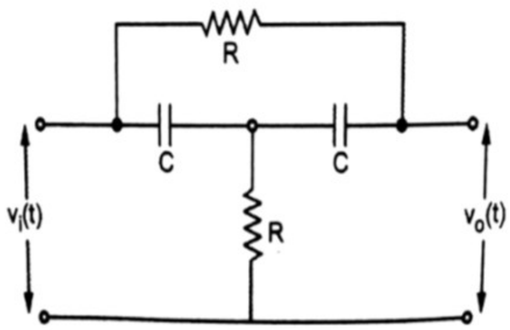
		OR			
	a	Find the state-tarannsition matrix for $A = \begin{bmatrix} 0 & -1 \\ +2 & -3 \end{bmatrix}$.	8	CO5	L3
	b	A single input single output system has the state and output equations $\dot{x} = \begin{bmatrix} 0 & 1 \\ -6 & -5 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} r$ $y = [5 \quad 0] x$ i) Determine its transfer function (ii) Find its state transition matrix.	12	CO5	L3

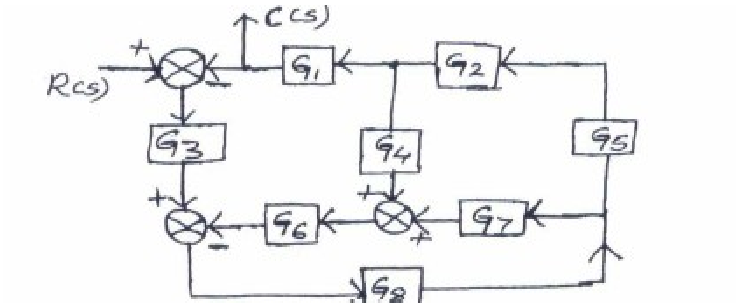
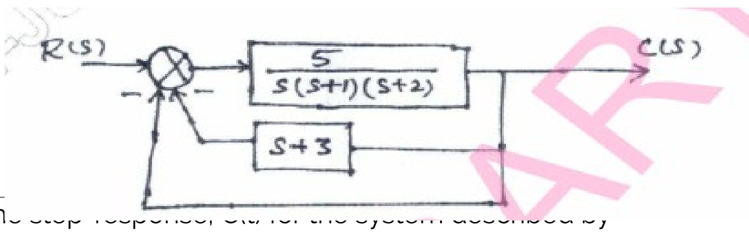
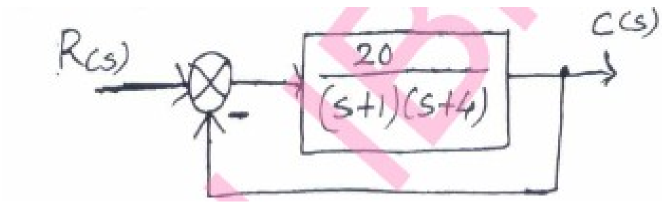
2. SEE Important Questions

Course:					Month / Year			
Crs Code:	1	Sem:		Marks:		Time:		
	Note	Answer all FIVE full questions. All questions carry equal marks.				-	-	
Module	Qno.	Important Question				**Marks**	**CO**	**Year**
1	1	For the mechanical system shown in below Fig. (i)Obtain its mathematical model .(ii)Write the performance equation (iii)Obtain its Force-Voltage and Force-current analogous circuits 				10	CO1	
	2	Distinguish closed loop control system from open loop control system with suitable examples.				10	CO1	
	3	Obtain the transfer function of the system shown in below Fig. 				10	CO1	
	4	Explain linear and non-linear control system.				10	CO1	
	5	For the mechanical system shown in Fig.Q1(b): i) Draw the mechanical network. ii) Obtain equations of motion. H.) Draw an electrical network based on force current analogy. 				10	CO1	

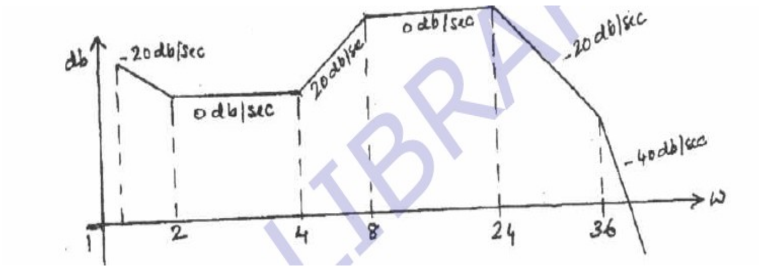
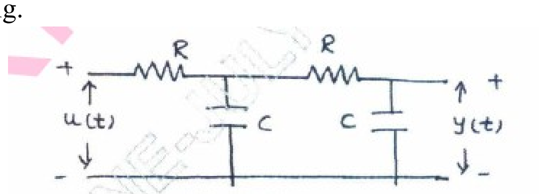
	6	For the circuit shown in below Fig 'IC' is the gain of an ideal amplifier. Determine the transfer function I(s) / V (s) 	10	CO1	
	7	For the circuit shown in below Fig 'IC' is the gain of an ideal amplifier. Determine the transfer function I(s) / V (s) 	10	CO1	
2	8	ApplyBlock diagram reduction technique to find the transfer function C(S)/ R(s) for the system shown 	10	CO2	
	9	Apply Block diagram reduction technique to find the transfer function C(S)/ R(s) for the system shown 	10	CO2	
	10	Apply Mason's Gain formula to find the transfer function for the	10	CO2	

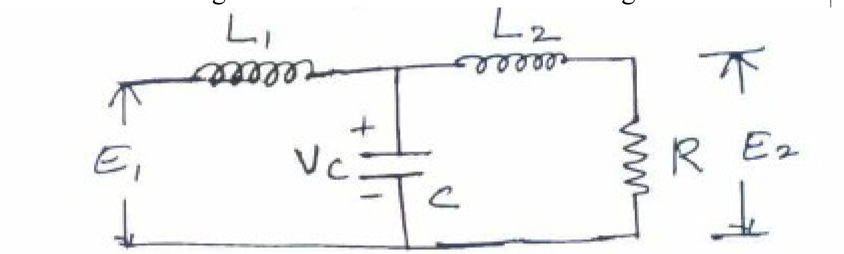
		signal flow graph shown  			
	11	Construct the signal flow graph for the block diagram shown Find the transfer function using Mason's gain formula.  	10	CO2	
	12	Construct the block diagram for the signal flow shown in Fig 14 and find the transfer function using block diagram reduction technique. Verify the answer using Mason's gain formula.  	10	CO2	
	13	Construct the signal flow graph for the electrical network shown in Fig and find the transfer function. Also verify the answer using block diagram reduction technique	10	CO2	



	14	Obtain C(s)/R(s) for the block diagram shown in below Fig using block diagram reduction techniques. 	10	CO2	
3	15	For the system shown in Fig. Find the : i) system type ii) static error constants kp, k_v and ka and iii) the steady state error for an input r(t) = 3 + 2t. 	10	CO3	
	16	Find the step response, c(t) for the system described by C(s) / R(s) = 4/ (S+ 4) Also find the time constant, rise time and settling time.	10	CO3	
	17	Write short notes on PI controller.	10	CO3	
	18	Derive the expression for unit step response for 1st order control system with closed loop transfer function K/(S+1/t)	10	CO3	
	19	Derive the expression for unit step response for 2nd order control system with closed loop transfer function K/(S+1/t)	10	CO3	
	20	Write short notes on PD controller.	10	CO3	
	21	List the standard test inputs used in control system and write their Laplace transform.	10	CO3	
	22	Find Kp, Kv, Ka and steady state error for a system with open loop transfer function as G(s) / H(s) = (10(s + 2)(s + 3)) / (s(s +1)(s + 4)(s + 5)) where the input is r(t) = 3 + t + t^2.	10	CO3	
	23	For the system shown in Fig, obtain closed loop transfer function, damping ratio natural frequency and expression for the output response if subjected to unit step input. 	10	CO3	

	24	Define rise time and maximum overshoot and write their formula.	10	CO3	
	25	For a given system G(s) / H(s) = 2 K / (s (s + 2)(s + 3)). Find the value of K to limit steady state error to 10 when input to system is $1+10t+20t^2$.	10	CO3	
	26	For a unity feedback control system with G(s) = 64/ (s(s + 9.6)) Write the output response to a unit step input. Determine: i) The response at t = 0.1 sec. ii) Settling time for ± 2% of steady state.	10	CO3	
	27	A control system with open loop transfer function $K(S+2)/(S^2+10S+20)$ produces 20% steady state error with unit step input. Determine the value of constant K.	10	CO3	
	28	Derive the expression for unit step response for 1st order control system with closed loop transfer function K/(S+1/t)	10	CO3	
	29	Derive the expression for unit step response for 2nd order control system with closed loop transfer function K/(S+1/t)	10	CO3	
4	30	Determine the ranges of K such that the characteristic equation : $S^3 +3(K + 1)S^2 + (7K + 5)S + (4K + 7) = 0$, has roots more negative than S = -1.	10	CO4	
	31	Find the range of K for which the system with closed loop transfer function $K / (S(S+2)(S^2+ S+1))$ is stable. For what value of K the system oscillates and what is the corresponding frequency of oscillation.	10	CO4	
	32	The open loop transfer function of a feedback control system is given by K/(S(S+2)(S+1)). Construct the root locus and find the range of K for which the closed loop system is stable. .	10	CO4	
	33	Check the;&ability of the given characteristic equation using Routh's method. $S^6 + 2S^5 + 8S^4 + 12S^3 + 20S^2 + 16S + 16 = 0$.	10	CO4	
	34	Mention few limitations of Routh's criterion	10	CO4	
	35	Construct the root locus of a control system with characteristic equation (S2+2S+2) + K(S+4)=0. Determine the stability of the closed loop system. Show that a part of root locus is a circle of radius √10 units with centre at (-4, 0).	10	CO4	
	36	Sketch the complete root locus of system having, G (s) = K / (**S(S +1)(S** + 2)(S + 3))	10	CO4	
	37	Consider the system with G(S)H(s) = . K / (S (S -1)(S+ 4)) Find whether S = —2 point is on root locus or not using angle condition.	10	CO4	
	38	Sketch the root locus plot for a negative feedback control system whose open loop transfer function is given by $G(s)H(s) = K / (s(s +3)(s^2 + 2s + 2))$ for all values of K ranging from 0 to infinity. Also find the value of K for a damping ratio of 0.5	10	CO4	
	39	Sketch the rough nature of the root locus of a certain control system whose C.E is given by $s^3 +9s^2 + Ks + K = 0$, comment on the stability.	10	CO4	
	40	Explain Rouths-Harwitz stability criterion.	10	CO4	
	41	$s^6 +4s^5 +3s^4 —16s^2 —64s —48 = 0$. Find the number of roots of this equation real part, zero real part and negative real part using RH criterion.	10	CO4	
	42	The open loop transfer function of a system is G(s) = K/ (s (1+ s)(1+ 0.1s)) Determine the values of K such that (i) gain margin = 10 dB ii) phase margin = 24°. Use Bode plot.	10	CO4	
	43	Derive the expression for resonant peak 'Mr' and corresponding resonant frequency `Wr' for a second—order under-damped system in frequency response analysis.	10	CO4	
	44	Sketch the Nyquist plot for a system with the open-loop transfer function : G(s)H(s) = (k (1+ 0.5s)(1 + s)) / ((1 + 10s)(s —1)) . Determine the range of values of 'K' for which the system is stable.	10	CO4	
	45	Explain Nyquist stability criteria	10	CO4	
	46	For a closed loop control system G(s) = 100 / (s (s+8), H(s) = 1. Determine the resonant peak and resonant frequency.	10	CO4	
	47	Explain lag-lead compensator network and briefly discuss the effects of lead-lag	10	CO4	

		compensator.			
	48	Using Nyquist stability criterion, find the closed loop stability of a negative feedback control system whose open-loop transfer function is given by $G(s)H(s) = 5 /(s(s - 1))$	10	CO4	
	49	For a unity feedback system $G(s) = 242((s+5))/ (s(s +1)(s^2 + 5s +121))$ Sketch the bode plot and find gain crossover freq,phase crossover freq, gain margin and phase margin.	10	CO4	
	50	Construct the Bode plot for the system with open loop transfer function $\frac{K}{S(S+1)(1+0.1S)}$ Determine the value of K such that (a) gain margin = 10db (b) Phase margin = 50^0.	10	CO4	
	51	Determine the transfer function of a system whose asymptotic Bode plot is as shown in fig 	10	CO4	
5	52	Find the state-tarannsition matrix for $A = \begin{bmatrix} 0 & -1 \\ +2 & -3 \end{bmatrix}$.	10	CO5	
	53	Obtain an appropriate state model for a system re mented by an electric circuit as shown in below Fig. 	10	CO4	
	54	linear time invariant system is characterized by the homogeneous state equation $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$ Compute the solution of homogeneous equation, assume the initial state vector. $X_0 = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$.	10	CO4	
	55	State the properties of state transition matrix.	10	CO4	
	56	Find the transfer function of the system having state model. $\dot{X} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$ and $y = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$	10	CO4	

	57	Obtain the state model for the system represented by the differential equation $\frac{d^3y(t)}{dt^3}+6\frac{d^2y(t)}{dt^2}+11\frac{dy(t)}{dt}+10y(t)=3u(t)$.		CO4	
	58	Obtain the state model of given electrical network shown in Fig. 		CO4	
	59	Find the state transition matrix for $A=\begin{bmatrix}0 & -1\\ 2 & -3\end{bmatrix}$.		CO4	
	60	single input single output system has the state and output equations i) Determine its transfer function (ii) Find its state transition matrix. $\dot{x}=\begin{bmatrix}0 & 1\\ -6 & -5\end{bmatrix}x+\begin{bmatrix}0\\ 1\end{bmatrix}r$ $y=[5 \quad 0]x$		CO4	
	61	Draw polar plot of G(s)H(s) = 100/ (s^2 +10S+100)	**10**	CO5	
	62	Draw the polar plot for the following open-loop transfer function G(S)H(s) = 1/ (1+ 0.1s)	**10**	CO5	
	63	Sketch the Nyquist plot for a system with the open-loop transfer function : G(s)H(s) = (k (1+ 0.5s)(1 + s)) / ((1 + 10s)(s —1)) . Determine the range of values of 'K' for which the system is stable.	**10**	CO5	
	64	Explain Nyquist stability criteria	**10**	CO5	
	65	Using Nyquist stability criterion, find the closed loop stability of a negative feedback control system whose open-loop transfer function is given by G(s)H(s) = 5 /(s(s —1))	**10**	CO5	

Course Outcome Computation

Academic Year:

Odd / Even semester

INTERNAL TEST	**T1**	**T2**	**T3**
Course Outcome			
QUESTION NO			
MAX MARKS			

USN-1		
USN-2		
USN-3		
USN-4		
USN-5		
USN-6		
Average CO Attainment		

LV Threshold : 3:>60%, 2:>=50% and <=60%, 1: <=49%
CO1 Computation :(2+2+2+3)/4 = 10/4=2.5

PO Computation

Program Outcome	PO1	PO3	PO3	PO1	PO12	PO12	PO6	PO1
Weight of CO - PO	3	1	3	2	2	3	3	1
Course Outcome								CO8
Test/Quiz/ Lab	T1			T2			T3	
QUESTION NO								
MAX MARKS								
USN-1								
USN-2								
USN-3								
USN-4								
USN-5								
USN-6								
Average CO Attainment								