Ref No:

## SRI KRISHNA INSTITUTE OF TECHNOLOGY BANGALORE



## COURSE PLAN

## Academic Year 2019-20

Program:	B E – Mechanical Engineering
Semester :	7
Course Code:	15ME73
Course Title:	CONTROL ENGINEERING
Credit / L-T-P:	04/3-2-0
Total Contact Hours:	54
Course Plan Author:	Mr. Harendra Kumar H V

## Academic Evaluation and Monitoring Cell

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## A. COURSE INFORMATION

#### **1. Course Overview**

Degree:	ME	Program:	ME
Semester:	VII	Academic Year:	2019-2020
Course Title:	CONTROL ENGINEERING	Course Code:	15ME71
Credit / L-T-P:	04/3-2-0	SEE Duration:	180 min
Total Contact Hours:	54 Hrs	SEE Marks:	80 Marks
CIA Marks:	20	Assignment	1 / Module
Course Plan Author:	Mr. Harendra Kumar H V	Sign	Dt:
Checked By:	Mr. Dinesh P	Sign	Dt:
CO Targets	CIA Target :90%	SEE Target:	85%

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. Identify 2 concepts per module as in G.

Mod	Content	Teachin	Identified Module	Blooms
ule		g Hours	Concepts	Learning
		-	Î	Levels
1	Introduction: Concept of automatic controls. Open loop and	7	Control, feedback,	L2
	closed loop systems. Concepts of feedback, requirements		controllers	
	of an ideal control systems			
	of an ideal control system,			
	Types of controllers-Proportional, Integral, Differential, Proportional			
	& Integral, Proportional Differential and Proportional Integral			
	Differential			
2	Controllers.	12	Mathanatian1	1.2
2	Modeling of Physical Systems : Mathematical Models of Mechanical,	13	Mathematical Model block and	L3
	Analogous Systems: Direct and inverse analogs for mechanical		signal diagram	
	thermal and fluid systems		signai ulagrani	
	Block diagram Algebra: General representation of a feedback control			
	system transfer functions rules of block diagram algebra reduction			
	of block diagram to obtain closed loop transfer function. Signal flow			
	graphs : Mason's gain formula			
3	Steady state operation: Steady state analysis for general block	13	Analysis of a	L4
-	diagram. for a control system, steady state characteristics, equilibrium		system	
	in a system.		5	
	Transient Response: Transient response and steady state analysis of			
	unit, step input, general operational representation for a differential			
	equation of control system, distinct, repeated and complex conjugate			
	zeros, general form of transient response, Routh's stability criterion			
	for a control system.			
	Root Locus Plots : Root locus method: Significance of Root locus,			
	angle and magnitude conditions, breakaway points, angles of			
	departure and arrival, construction of Root locus using general rules			
	and steps, Lead and Lag compensation	1.4	. 1	1.4
4	Frequency Domain Analysis: Relationship between time and	14	stability analysis	14
	requency response, Polar plot, Bode's Plot, Nyquist plot and Nyquist			
5	Stability criterion, Kelative Stability, Phase and Gain Margins	7	transiant and at 1	1.2
5	System Compensation and State variable Characteristics of Linear Systems (Series and feedback compensation Introduction to state	/	state time response	Lo
	concents state equation of linear continuous data system Matrix		state time response	
	representation of state equations controllability and observability			
	Kalman and			
	Gilberts test			
-	Total	54	-	-

#### **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	Availability
		in book	
Α	Text books (Title, Authors, Edition, Publisher, Year.)	-	-
1,2,4,5	Control Systems by Anand Kumar PHI,2nd edition	1,2,4,5	In Lib
3	Control Systems, Principles and Design by M.Gopal, McGaw Hill, 4th Edition,	3	In Lib
	2012		
В	Reference books (Title, Authors, Edition, Publisher, Year.)	-	-
3	Automatic Control Systems, FaridGolnaraghi, Benjamin C. Kuo Wiley 9 th	3	In dept
	Edition, 2010		
4	Control Systems Engineering Modern Control Systems Norman S. Nise	4	In dept
	Richard C Dorf et al Wiley Pearson 4 th Edition, 2004,11 th Edition, 2008		
1,2,4,5	Control Systems Engineering M.Gopal McGaw Hill 4 th Edition, 2012	1,2,4,5	In dept
	S. Salivahanan et al Pearson 1 st Edition, 2015Automatic Control Systems		
C	Concept Videos or Simulation for Understanding		
1	encyclopedia.che.engin.umich.edu >		
2	https://www.powermag.com >		
3	https://www.acciona-energia.co\		
4	https://www.delta-t.co.uk >		
5	https://study.com > academy		
5	https://www.studentenergy.org > t		

#### 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 . . .

Modu les	Course	Course Name	Topic / Description	Sem	Remarks	Blooms Level
4	15MAT21	Engineering Mathematics	Engineering calculus	II		Level L2

#### **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.

1.0		, in 2		
Modu	Topic / Description	Area	Remarks	Blooms
les				Level

## **B. OBE PARAMETERS**

#### **1. Course Outcomes**

Expected learning outcomes of the course, which will be mapped to POs. Identify a max of 2 Concepts per Module. Write 1 CO per Concept.

Modu	Course	Course Outcome	Teach.	Concept	Instr	Assessment	Blooms'
les	Code.#	At the end of the course, student	Hours		Method	Method	Level
		should be able to					
1	15ME73.1	Understand the effects of feedback and	3	Control	Chalk and	Assignmen	L2

		types of feedback control systems		,feedback	board	t and Slip	Understand
1	15ME73.2	Recognize control system and its types, control actions	4	controllers	Chalk and board	Assignmen t and Slip Test	L2 Understand
2	15ME73.3	Apply the system governing equations for physical models	7	Modelling systems	Chalk and board	Assignmen t and Slip Test	L3 Apply
2	15ME73.4	Calculate the gain of the system using block diagram and signal flow graph	6	Block and signal flow diagram	Chalk and board	Assignmen t and Slip Test	L3 Apply
3	15ME73.5	Apply response of 1st and 2nd order systems	7	Analysis of a system	Chalk and board	Assignmen t and Slip Test	L3 Apply
3	15ME73.6	Analysis of system using root locus plots.	6	stability analysis	Chalk and board	Assignmen t and Slip Test	L4 Analyse
4	15ME73.7	<ul> <li>To analyze stability of a control system using Nyquist plot.</li> <li></li> </ul>	7	Frequency response analysis using polar plot.	Chalk and board	Assignmen t and Slip Test	L4 Analyse
4	15ME73.8	Analyse stability analysis using Bode plots	7	Frequency response analysis using bode plot.	Chalk and board	Assignmen t and Slip Test	L4 Analyse
5	15ME73.9	state equations to study the controllability and observability	3	system compensator s	Chalk and board	Assignmen t and Slip Test	L3 Apply
5	15ME73.10	Different system compensators and variable characteristics of linear systems.	4	characteristic s	Chalk and board	Assignmen t and Slip Test	L2 understand

### 2. Course Applications

Modu	Application Area	CO	Level
les	Compiled from Module Applications.		
1	Thermostat, thermoresister	CO1	L2
1	Industrial control panel, sensors	CO2	L2
2	Animal digestive system, solar system,	CO3	L3
2	Antenna control, amplifiers, digital filters	CO4	L3
3	Circuits for electrical systems	CO5	L3
4	synthesis of systems and to the prediction of the transient response.	CO6	L4
4	$\Box$ synthesis of systems and to the prediction of polar plot.	CO7	L4
5	synthesis of systems and to the prediction of bode plot.	CO8	L4
5	Multiple system application,	CO9	L3
	multivariable systems	CO10	L2

### 3. Mapping And Justification

CO – PO Mapping with mapping Level along with justification for each CO-PO pair. To attain competency required (as defined in POs) in a specified area and the knowledge & ability required to accomplish it.

Mod	Map	Mapping Mapping		Justification for each CO-PO pair	Lev			
ules	s Level		Level		el			
-	CO	PO	-	'Area': 'Competency' and 'Knowledge' for specified 'Accomplishment'	-			
1	CO1	PO1	L2	'Engineering Knowledge:'Acquisition of Engineering_Knowledge is required to	L2			
				understand the different energy sources and there utilization to accomplish solutions				
				complex engineering_problems in Mechanical Engineering.				
1	CO1	PO2	L3	'Problem Analysis': Analyzing problems require knowledge / understanding	L2			

				different conversions of energy engineering fundamentals to accomplish solutions	
				to complex engineering problems in Mechanical engineering.	
2	CO2	PO1	L3	'Engineering Knowledge:'Acquisition of Engineering_Knowledge is required to	L2
				understand the different Thermal energy storage systems to accomplish solutions to	
				complex engineering_problems in Mechanical Engineering	
2	CO2	PO2	L3	'Problem Analysis': Analyzing problems require knowledge / understanding	L3
				storage systems to accomplish solutions to complex engineering problems in	
				Mechanical engineering.	
3	CO3	PO1	L2	'Engineering Knowledge:'Acquisition of Engineering_Knowledge is required to	L2
				understand the diesel engine power plant in Mechanical Engineering.	
3	CO3	PO2	L2	'Problem Analysis': Analyzing problems require knowledge / understanding diesel	L2
				engine power plant, to accomplish solutions to complex engineering problems in	
				Mechanical engineering.	
4	CO4	PO1	L3	'Engineering Knowledge:'Acquisition Knowledge of storage plants is required to	L3
				understand hydroelectric power plant in Mechanical Engineering.	
4	CO4	PO2	L3	'Problem Analysis': Analyzing problems require knowledge / understanding storage	L2
				plants in the hydro power plant systems to complex engineering problems in	
				Mechanical engineering.	
5	CO5	PO1	L3	'Engineering Knowledge:'Acquisition of Engineering_Knowledge is required to	L2
				understand the basic concept of solar power plant to accomplish solutions to	
				complex engineering problems in Mechanical Engineering.	
5	CO5	PO2	L3	'Problem Analysis': Analyzing problems in an solar Pv modules require	L2
				knowledge / understanding problems in the soalr power plant in Mechanical	
				engineering.	
6	CO6	PO1	L2	'Engineering Knowledge:'Acquisition of Engineering_Knowledge is required to	L2
				understand the energy conversions from alternate source of energy in an complex	
				engineering problems in Mechanical Engineering.	
6	CO6	PO2	L3	'Problem Analysis': Analyzing problems require knowledge / understanding	L2
				problems in conversion systems in an environment.	
7	CO7	PO1	L3	'Engineering Knowledge:'Acquisition of Engineering_Knowledge is required to	L2
				understand the tide and wave enrgy to accomplish solutions to complex engineering	
				problems in Mechanical Engineering.	
7	CO7	PO2	L3	'Problem Analysis': Analyzing problems require knowledge / understanding	L3
				problems in the different types of wave and tidal energy to complex engineering	
				problems in Mechanical engineering.	
8	CO8	PO1	L2	'Engineering Knowledge:'Acquisition of Engineering_Knowledge is required to	L2
				understand the different biomass gasification process to complex engineering	
				problems in Mechanical Engineering.	
8	CO8	PO2	L2	Problem Analysis': Analyzing problems require knowledge / understanding	L2
				problems in the different gasifiers s in Mechanical engineering	
9	CO9	PO1	L2	'Engineering Knowledge:'Acquisition of Engineering_Knowledge is required to	L2
				understand the fuel cell principles to complex engineering_problems in Mechanical	
				Engineering.	
9	CO9	PO2	L2	Problem Analysis': Analyzing problems require knowledge / understanding	L2
				problems in the different types of fuel cells to complex engineering problems in	
				Mechanical engineering	

#### 4. Articulation Matrix

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

-	-	Course Outcomes	Program Outcomes												-			
Modu	CO.#	At the end of the course student	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PS	PS	PS	Lev
les		should be able to	1	2	3	4	5	6	7	8	9	10	11	12	01	<b>O</b> 2	03	el
1	15ME73.1	Evaluate time and space complexity	2	3														L2

		and calculate performance								1	Und
										e	ersta
1	15ME732	Understanding searching and sorting	3	2							L3
	1011127012	enderstanding searching and sorting		-							App
											ly
2	15ME73.3	Use AND / OR graph, spanning trees	2	3							L2
										1	Und
										e	ersta
			_	_							nd
2	15ME73.4	Use Backtracking technique for	2	3							L3
		searching a set of solutions of for								4	App
3	15ME73 5	Apply Gready method for finding	3	2				_			IY I 3
5	15101275.5	optimal solution	5	2							L5 Ann
		optimier solution								1	lv
3	15ME73.6	Circuits for electrical systems	3	2							L3
		5									App
											ly
4	15ME73.7	$\Box$ To analyze stability of a	2	3							L2
		control system using Nyquist								1	Und
		plot.								e	ersta
4	1510572.0		2	2							nd
4	15ME/3.8	Analyse stability analysis using	3	2						1	L2 Und
		Bode plots								ſ	ersta
											nd
5	15ME73.9	Able to differentiate NP – Hard and	2	1							L2
		NP – Complete Problems								1	Und
		-								e	ersta
											nd
5	15ME73.10	Analyse stability analysis with	3	2							
		different tests									
-	15ME73	Average attainment (1, 2, or 3)									

### 5. Curricular Gap and Content

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

Modu	Gap Topic	Actions Planned	Schedule Planned	Resources Person	PO Mapping
les					
1	Root locus plot	NPTEL Videos	-	-	PO2
3	Nyquist Plot	NPTEL Videos	-	-	PO2
5	Bode plot	NPTEL Videos	12/11/2019	Self	PO2

#### 6. Content Beyond Syllabus

Topics & contents required (from A.5) not addressed, but help students for Placement, GATE, Higher Education, Entrepreneurship, etc.

Modu	Gap Topic	Area	Actions Planned	Schedule Planned	<b>Resources Person</b>	PO Mapping
les						
3	Construction of an	Placement,	Presentation	9/9/2019	Self	PO5
	array and PV Module	GATE,				
		Higher Study				

## **C. COURSE ASSESSMENT**

### **1. Course Coverage**

Assessment of learning outcomes for Internal and end semester evaluation. Distinct assignment for each student. 1 Assignment per chapter per student. 1 seminar per test per student.

Mod	Title	Teach.		No. o	of quest	ion in I	Exam		CO	Levels
ules		Hours	CIA-1	CIA-2	CIA-3	Asg	Extra	SEE		
							Asg			
1	Introduction	7	2	-	-	1	1	2	CO1, CO2	L2,L2
2	Modeling of Physical Systems	13	2	-	-	1	1	2	CO3, CO4	L3,L3
	Block diagram Algebra									
	Signal flow graphs									
3	Steady state operation	13	-	2	-	1	1	2	CO5, CO6	L3,L4
	Transient Response									
	Root Locus Plots									
4	Frequency Domain Analysis	14	-	2	-	1	1	2	CO7, C08	L4,L4
5	System Compensation and State	7	-	-	4	1	1	2	CO9, CO10	L3,L2
	Variable Characteristics of Linear									
	Systems									
-	Total	54	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.

Mod	Evaluation	Weightage in	СО	Levels
ules		Marks		
1, 2	CIA Exam – 1	15	CO1, CO2, CO3, CO4	L2, L3, L2,L3
3, 4	CIA Exam – 2	15	CO5, CO6, CO7,	L4,L2,L2
5	CIA Exam – 3	15	CO8, CO9,CO10	L2, L2
1, 2	Assignment - 1	05	CO1, CO2, CO3, CO4	L2, L3, L2,L3
3, 4	Assignment - 2	05	CO5, CO6, CO7,	L3,L2,L2
5	Assignment - 3	05	CO8, CO9, CO10	L2, L2
1, 2	Seminar - 1	00		
3, 4	Seminar - 2	00		
5	Seminar - 3	00		
	-			
	Final CIA Marks	20	CO1 to CO10	L2, L3

## **D1. TEACHING PLAN – 1**

### Module – 1

Title:	Introduction	Appr	7 Hrs
		Time:	
а	Course Outcomes	-	Blooms
-	The student should be able to:	-	Level
1	Understand the effects of feedback and types of feedback control systems	CO1	L2
2	Recognize control system and its types, control actions	CO2	L2
b	Course Schedule	-	-
Class No	Module Content Covered	CO	Level
1	Introduction	C01	L2
2	Concept of automatic controls,	C01	L2
3	Open loop and closed loop systems	C01	L2
4	Concepts of feedback, requirements of an ideal control system,	C01	L2
5	Types of controllers-Proportional, Integral	C02	L2
6	Differential, Proportional & Integral	C02	L2

7	Proportional Differential and Proportional Integral Differential controllers	C02	L2
с	Application Areas	CO	Level
1	Thermostat, thermoresister	CO1	L3
2	Industrial control panel, sensors	CO2	L4
	-		
d	Review Questions	-	-
1	Define control system with an examples	CO1	L2
2	Explain the concept of automatic controls, with examples	CO1	L2
3	Explain the concepts of feedback with examples	CO1	L2
4	Explain requirements of an ideal control system.	CO1	L2
5	Write the different types of controllers.	CO2	L2
6	Explain in detail proportional integral, proportional differential controllers.	CO2	L2
7	Explain in detail Proportional Differential controllers	CO2	L2
8	Explain in detail Proportional Integral Differential controllers.	CO2	L2
e	Experiences	-	-
1		CO1	L2
2			
3			
4		CO3	L3
5			

### Module – 2Frequency Domain Analysis: Relationship between time and frequency response,

Title:	Modeling of Physical Systems	Appr Time:	13 Hrs
9	Course Outcomes		Blooms
-	The student should be able to:	_	Level
1	Apply the system governing equations for physical models	CO3	I.4
2	Calculate the gain of the system using block diagram and signal flow graph	CO4	L3
			-
b	Course Schedule	-	-
Class No	Module Content Covered	CO	Level
1	Modeling of Physical Systems	CO3	L4
2	Mathematical Models of Mechanical, Hydraulic and Pneumatic Systems.	CO3	L4
3	Mathematical Models of Electrical, thermal systems.	CO3	L4
4	Analogous Systems: Direct and inverse analogs	CO3	L4
5	Analogous Systems: for mechanical, thermal and fluid systems.	CO3	L4
6	Block diagram	CO4	L3
7	General representation of a feedback control system, transfer functions,	CO4	L3
8	rules of block diagram algebra, reduction of block diagram to obtain closed loop transfer function	CO4	L3
9	problems	CO4	L3
10	problems	CO4	L3
11	Signal flow graphs : Mason's gain formula	CO4	L3
12	problems	CO4	L3
13	problems	CO4	L3
с	Application Areas	CO	Level
1	Animal digestive system, solar system,	CO3	L3
2	Antenna control, amplifiers, digital filters	CO4	L4
d	Review Questions	-	-
1	obtain differential equations for the mechanical system shown. Also draw equivalent force-voltage and force-current circuits using analogues quantities.	CO3	L3
2	liquid level system in which q, is inflow rate, qo is out flow rate, R is hydraulic	CO4	L3

	resistance, C is hydraulic capacitance and h is head of liquid. Obtain transfer		
	function.		
3	Obtain differential equation for RLC circuit.	CO3	L3
4	Obtain closed loop transfer function of the block diagram shown in Fig. using block diagram reduction techniques	CO4	L4
5	Draw signal flow graph for the system shown in Fig. and find using Mason's gain formula.	CO4	L3
6	Write the differential equations governing the behaviour of the mechanical system Also obtain the analogous electrical circuit based on force voltage analogy and loop equations	CO3	L4
7	Obtain the transfer function of field controlled DC motor	CO3	L3
8	reduce the block diagram shown in Fig.Q3(a) and obtain the transfer function	CO3	L3
9	fnd the transfer function by using Mason's gain formula for the signal flow graph shown in fig.	CO4	L4
10	A units feedback system characterized by an open loop transfer function Determine the following, when the system is subjected to a unit step input:i) Undamped natural frequently ii) Damping ratio iii) Peak overshoot iv) Peak time v) Settling time	CO3	L3
11	fnd the transfer function by using Mason's gain formula for the signal flow graph shown in fig.	CO4	L4
12	reduce the block diagram shown in Fig.Q3(a) and obtain the transfer function	CO4	L3
13	fnd the transfer function by using Mason's gain formula for the signal flow graph shown in fig.	CO4	L3
14	reduce the block diagram shown in Fig.Q3(a) and obtain the transfer function	CO4	L4
15	fnd the transfer function by using Mason's gain formula for the signal flow graph shown in fig.	CO4	L4
16	reduce the block diagram shown in Fig.Q3(a) and obtain the transfer function	CO4	L4
17	Write the differential equations governing the behaviour of the mechanical system	CO3	L4
18	Write the differential equations governing the behaviour of the mechanical system.	CO3	L4
19	obtain the analogous electrical circuit based on force voltage analogy and loop equations	CO3	L4
20	obtain the analogous electrical circuit based on force voltage analogy and loop equations	CO3	L4
e	Experiences	-	-
1		CO1	L2
2			
3			
4		CO3	L3
5			

## E1. CIA EXAM – 1

### a. Model Question Paper - 1

Crs C	Code:	15ME73	Sem:	7	Marks:	15	Time: 75	5 minutes		
Cour	se:					·				
-	-	Note: Answ	wer any 2 qu	estions, ea	ch carry equal	marks.		Marks	СО	Level
1	a	Define con	trol system w	ith an exam	mples			3	CO1	L1
	b	Explain the	concept of a	utomatic c	ontrols, with exa	mples		2	CO1	L2
	с	Explain in	detail Propor	tional Integ	gral Differential c	controllers.		2	CO1	L3
2	a	Explain in	detail Propor	tional Diff	erential controlle	rs		3	CO1	L2
	b	Explain rec	uirements of	an ideal c	ontrol system.			2	CO1	L4
	с	Explain in	detail propor	tional integ	gral, proportional	differentia	l controllers.	2	CO1	L3
3	a	Write the d	ifferential eq	uations go	verning the behav	viour of the	mechanical system.	4	CO2	L3
	b	obtain the	btain the analogous electrical circuit based on force voltage analogy and lo						CO2	L3
		equations								

	c	obtain the analogous electrical circuit based on force voltage analogy and loop equations	2	CO2	L3
4	a	obtain differential equations for the mechanical system shown. Also draw	4	CO2	L3
		equivalent force-voltage and force-current circuits using analogues quantities.			
	b	liquid level system in which q, is inflow rate, qo is out flow rate, R is hydraulic	2	CO2	L3
		resistance, C is hydraulic capacitance and h is head of liquid. Obtain transfer			
		function.			
	с	Obtain differential equation for RLC circuit.	2	CO2	L2

### b. Assignment -1

Note: A distinct assignment to be assigned to each student.

					Mode	el Assignmer	nt Questic	ons				
Crs Co	ode: 15	5ME73	Sem:	VI	I	Marks:	5		Time:	90 – 120 r	ninutes	
Course	e: D	esign ar	d Analysis	of Algo	rithms							
Note:	Each stud	dent to a	nswer 2-3	assignm	ents. Eac	ch assignmei	nt carries	equal n	nark.			
SNo	US	N			Assi	gnment Des	scription			Marks	СО	Level
1			Define con	trol syst	em with	an examples	s			5	CO1	L2
2			Explain the	e concep	t of auto	matic contro	ols, with e	example	es	5	CO1	L2
3			Explain the	e concep	ts of feed	dback with e	examples				CO1	L2
4			Explain rec	quireme	nts of an	ideal contro	l system.			5	CO1	L2
5			Write the d	lifferent	types of	controllers.	-			5	CO1	L2
6			Explain ii	n detai	l propo	rtional inte	egral, pro	oportio	nal differenti	al 5	CO1	L2
			controllers	•								
7			Explain in	detail Pr	roportion	al Different	ial control	ollers		5	CO1	L2
8			Explain in	detail Pr	roportion	al Integral I	Differentia	al contr	ollers.	5	CO1	L2
9			obtain diff	erential	equation	ns for the n	nechanica	al syste	m shown. Als	io 5	CO2	L3
			draw equ	ivalent	force-v	oltage and	force-cu	urrent	circuits usir	g		
10			analogues of	quantitie	es.							
10			liquid leve	1 system	1 in whic	h q, is inflo	w rate, qo	o is out	t flow rate, R	1S 5	CO2	L3
			hydraulic r	esistanc	e, C is h	ydraulic cap	acitance a	and h is	s head of liqui	1.		
11			Obtain diff	Ister Tun	ction.	for DLC air	it			5	CO2	1.2
11			Obtain alar		transfor	function of	the block	diama	m chourn in Ei	5	C02	
12			Uplain clos	sed loop	m raduat	ion techniqu		ulagra	III SHOWII III FI	g. 3	002	LS
12			Drow sign	d flow	groph fo	r the system	es n chown	in Fig	and find usin	a 5	CO2	12
15	,		<u>J</u> raw signal flow graph for the system shown in Fig. and find using Mason's gain formula.			g J	02	LS				
14			Write the	differe	ntial eq	uations gov	verning t	the bel	haviour of th	ie 5	CO2	L3
			mechanical	l system	Also ob	tain the anal	ogous ele	ectrical	circuit based of	n		
			force volta	ge analo	gy and lo	oop equatior	ıs					
15			Obtain the	transfer	function	of field con	trolled D	C moto	r	5	CO2	L3
16			reduce the	block d	liagram	shown in Fi	ig.Q3(a) a	and obt	ain the transfe	er 5	CO2	L3
			function									
17			fnd the tra	nsfer fur	nction by	y using Mas	on's gain	formul	a for the sign	al 5	CO2	L3
			flow graph	shown	in fig.							
18			A units fo	eedback	system	characteriz	ed by a	in oper	n loop transfe	er 5	CO2	L3
			function									
			Determine	the foll	owing, v	when the sy	stem is su	ubjecte	d to a unit ste	p		
			input:i) U	ndamped	d natura	I frequently	y 11) Dar	mping	ratio 111) Pea	k		
10			oversnoot i	IV) Peak	time v) :	Settling time	<u>}</u>	C	. C	1 5	<u> </u>	1.2
19			flow graph	shown	nction by	y using Mas	on's gain	formu	a for the sign	al 5	02	L3
20			reduce the	block d	liagram	shown in Fi	a <b>03</b> (a) a	and obt	ain the transfe	ar 5	CO2	13
20			function	DIOCK U	nagrani	Shown in 11	$\log(a) a$			<i>л 5</i>	02	1.5
21			fnd the tra	nsfer fu	nction by	v using Mas	on's gain	formul	a for the sign	al 5	CO2	L3
			flow graph	shown	in fig.	0	8			-		
22			reduce the	block d	liagram	shown in Fi	ig.Q3(a) a	and obt	ain the transfe	er 5	CO2	L3
			function		C							
23			fnd the tra	nsfer fu	nction by	y using Mas	on's gain	formul	a for the sign	al 5	CO2	L3
			flow graph	shown i	in fig.	-	-		2			

24	reduce the block diagram shown in Fig.Q3(a) and obtain the transfer function	5	CO2	L3
25	Write the differential equations governing the behaviour of the mechanical system	5	CO2	L3
26	Write the differential equations governing the behaviour of the mechanical system.	5	CO2	L3
27	obtain the analogous electrical circuit based on force voltage analogy and loop equations	5	CO2	L3
28	obtain the analogous electrical circuit based on force voltage analogy and loop equations	5	CO2	L3
29	Obtain closed loop transfer function of the block diagram shown in Fig. using block diagram reduction techniques	5	CO2	L3
30	Draw signal flow graph for the system shown in Fig. and find using Mason's gain formula.	5	CO2	L3
31	Write the differential equations governing the behaviour of the mechanical system Also obtain the analogous electrical circuit based on force voltage analogy and loop equations	5	CO2	L3
32	Obtain the transfer function of field controlled DC motor	5	CO2	L3
33	reduce the block diagram shown in Fig. and obtain the transfer function	5	CO2	L3
34	fnd the transfer function by using Mason's gain formula for the signal flow graph shown in fig.	5	CO2	L3
35	A units feedback system characterized by an open loop transfer function Determine the following, when the system is subjected to a unit step input:i) Undamped natural frequently ii) Damping ratio iii) Peak overshooti v) Peak time v) Settling time	5	CO2	L3
36	fnd the transfer function by using Mason's gain formula for the signal flow graph shown in fig.	5	CO2	L3
37	reduce the block diagram shown in Fig. and obtain the transfer function	5	CO2	L3
38	fnd the transfer function by using Mason's gain formula for the signal flow graph shown in fig.	5	CO2	L3
39	reduce the block diagram shown in Fig. and obtain the transfer function	5	CO2	L3
40	reduce the block diagram shown in Fig.Q3(a) and obtain the transfer function	5	CO2	L3
41	Write the differential equations governing the behaviour of the mechanical system	5	CO2	L3
42	Write the differential equations governing the behaviour of the mechanical system.	5	CO2	L3
43	reduce the block diagram shown in Fig. and obtain the transfer function	5	CO2	L3
44	Write the differential equations governing the behaviour of the mechanical system	5	CO2	L3
45	Write the differential equations governing the behaviour of the mechanical system.	5	CO2	L3

## **D2. TEACHING PLAN - 2**

## Module – 3

Title:	Steady state operation, Transient Response, Root Locus Plots	Appr	13 Hrs
		Time:	
a	Course Outcomes	-	Blooms
-	The student should be able to:	-	Level
1	Apply response of 1st and 2nd order systems	CO5	L3
2	Analysis of system using root locus plots.	CO6	L4
b	Course Schedule		
Class No	Module Content Covered	CO	Level
1	Steady state analysis for general block diagram.	CO5	L3
2	control system, steady state characteristics	CO5	L3
3	equilibrium in a system	CO5	L3
4	Transient response and steady state analysis of unit, step input,	CO5	L3
		1	

	equation of control system,		
6	Distinct, repeated and complex conjugate zeros, general form of transient response	CO5	L3
7	Routh's stability criterion for a control system.	CO6	L4
8	Significance of Root locus, angle and magnitude conditions	CO6	L4
9	breakaway points, angles of departure and arrival	CO6	I.4
10	construction of Root locus using general rules and steps	CO6	I.4
10	Lead and Lag compensation	C06	
12	nrohlems	C06	
12	problems	C00	L4 L4
15	problems	000	L/ <del>1</del>
C	Application Areas	CO	Level
1	Circuits for electrical systems	CO5	Level I 3
2	synthesis of systems and to the prediction of the transient response	CO5	LJ LA
2	synthesis of systems and to the prediction of the transient response.	000	LŦ
d	Review Auestions	_	_
1 u	Obtain response equation for a first order mechanical system subjected to unit step	CO5	L3
1	input.	005	15
2	Define the following terms:	CO5	L3
-	ii) Delay time	005	15
	i) Rise time		
	iv)Maximum overshoot		
	iii) Settling time		
3	Discuss on stability of system	CO5	L3
1	Obtain response equation for a first order mechanical system subjected to unit step	CO5	13
+	input	005	1.5
5	Discuss the Value of K for phase margin	C06	Ι <i>Δ</i>
6	Discuss the Value of K for gain margin	C06	
7	Explain the effect of addition of poles and zero's to the system	C05	L4 I3
/ Q	Discuss the Limiting value of K for system to be stable	CO5	
0	Even loin Douth Hummitz oritorion for stability of a control system	C00	L4 L2
9	Obtain response equation for a first order mechanical system subjected to unit star	<u>CO5</u>	L3 L2
10	obtain response equation for a first order mechanical system subjected to unit step	COS	L3
11	Sketch Root Locus plot for the unity feedback system whose open loop transfer	CO6	L4
	function on stability of system.		
12	Sketch Root Locus plot for the unity feedback system whose open loop transfer	CO6	L4
	function on stability of system.		
13	Sketch Root Locus plot for the unity feedback system whose open loop transfer	CO6	14
10	function on stability of system.	000	2.
14	Sketch Root Locus plot for the unity feedback system whose open loop transfer	CO6	Ι4
	function on stability of system.	000	2.
15	Sketch Root Locus plot for the unity feedback system whose open loop transfer	CO6	L4
	function on stability of system.		
16	Sketch Root Locus plot for the unity feedback system whose open loop transfer	CO6	L4
	function on stability of system.		
17	Discuss on stability of system.	CO6	L4
18	Obtain response equation for a first order mechanical system subjected to unit step	CO6	L4
	input.		
19	Discuss the Value of K for phase margin	CO6	L4
20	Discuss the Value of K for gain margin	CO6	L4
21	Sketch Root Locus plot for the unity feedback system whose open loop transfer	CO6	L4
	function on stability of system.		
22	Sketch Root Locus plot for the unity feedback system whose open loop transfer	CO6	L4
	function on stability of system.		
23	Sketch Root Locus plot for the unity feedback system whose open loop transfer	CO6	L4
	function on stability of system.		
24	Sketch Root Locus plot for the unity feedback system whose open loop transfer	CO6	L4
	function on stability of system.		
25	Sketch Root Locus plot for the unity feedback system whose open loop transfer	CO6	L4
	function on stability of system.		
26	Sketch Root Locus plot for the unity feedback system whose open loop transfer	CO6	L4

	function on stability of system.		
27	Sketch the root locus plot for the system whose open loop transfer function	CO6	L4
28	Sketch the root locus plot for the system whose open loop transfer function	CO6	L4
29	Sketch the root locus plot for the system whose open loop transfer function	CO6	L4
30	Sketch the root locus plot for the system whose open loop transfer function	CO6	L4
31	Explain the following:	CO6	L3
	i) Lead compensator ii) Lag compensator		
e	Experiences	-	-
1			
2			
3			
4			
4			

## Module – 4

Title:	Frequency Domain Analysis:	Appr Time:	14 Hrs
а	Course Outcomes	-	Blooms
-	The student should be able to:	_	Level
1	$\Box$ To analyze stability of a control system using Nyquist plot.	CO7	L4
2	Analyse stability analysis using Bode plots	CO8	L4
b	Course Schedule		
Class No	Module Content Covered	CO	Level
1	Relationship between time and frequency response,	CO7	L4
2	Polar plot, Phase and Gain Margins	CO7	L4
3	problems	CO7	L4
4	problems	CO7	L4
5	problems	CO7	L4
6	problems	CO7	L4
7	problems	CO7	L4
8	Nyquist plot and Nyquist stability criterion, Relative Stability	CO8	L4
9	Nyquist plot ,Phase and Gain Margins	CO8	L4
10	problems	CO8	L4
11	problems	CO8	L4
12	problems	CO8	L4
13	problems	CO8	L4
14	problems	CO8	L4
с	Application Areas	СО	Level
1	□ synthesis of systems and to the prediction of polar plot.	CO8	L4
2	synthesis of systems and to the prediction of bode plot.	CO7	L4
d	Review Questions	-	-
1	Discuss the Value of K for phase margin	CO7	L4
2	Sketch the bode plot for a unity feed-back system, whose open loop transfer function	CO7	L4
3	Sketch the bode plot for a unity feed-back system, whose open loop transfer	CO8	L4
	Discuss the gain and phase cross over frequencies	C07	I A
5	Discuss the gain and phase margin	CO8	
6	Discuss the gain and phase margin.	C08	I 4
7	Sketch the hode plot for a unity feed back system, whose open loop transfer	C07	
	function		L.T.
8	Sketch the bode plot for a unity feed-back system, whose open loop transfer function	CO7	L4
9	Sketch the bode plot for a unity feed-back system, whose open loop transfer	CO7	L4

	function		
10	Sketch the bode plot for a unity feed-back system, whose open loop transfer function	CO7	L4
11	Plot the Nyquit diagram for the open loop transfer function	CO8	L4
12	Plot the Nyquit diagram for the open loop transfer function	CO8	L4
13	Plot the Nyquit diagram for the open loop transfer function	CO8	L4
14	Plot the Nyquit diagram for the open loop transfer function	CO8	L4
15	Plot the Nyquit diagram for the open loop transfer function	CO8	L4
16	Plot the Nyquit diagram for the open loop transfer function	CO8	L4
17	Plot the Nyquit diagram for the open loop transfer function	CO8	L4
18	Plot the Nyquit diagram for the open loop transfer function	CO8	L4
19	Plot the Nyquit diagram for the open loop transfer function	CO8	L4
20	Plot the Nyquit diagram for the open loop transfer function	CO8	L4
21	Plot the Nyquit diagram for the open loop transfer function	CO8	L4
22	Sketch the bode plot for a unity feed-back system, whose open loop transfer function	CO7	L4
23	Sketch the bode plot for a unity feed-back system, whose open loop transfer function	CO7	L4
24	Sketch the bode plot for a unity feed-back system, whose open loop transfer function	CO7	L4
25	Sketch the bode plot for a unity feed-back system, whose open loop transfer function	CO7	L4
26	Sketch the bode plot for a unity feed-back system, whose open loop transfer function	CO7	L4
27	Sketch the bode plot for a unity feed-back system, whose open loop transfer function	CO7	L4
28	Sketch the bode plot for a unity feed-back system, whose open loop transfer function	CO7	L4
29	Sketch the bode plot for a unity feed-back system, whose open loop transfer function	CO7	L4
30	Sketch the bode plot for a unity feed-back system, whose open loop transfer function	CO7	L4
e	Experiences	-	-
1		CO7	L2
2			
3			
4		CO8	L3
5			

## **E2. CIA EXAM – 2**

## a. Model Question Paper - 2

Crs Code:		15ME73	Sem:	VII	Marks:	15	Time:	75 minutes		
Cour	se:	Steady state	Steady state operation, Transient Response, Root Locus Plots, Frequency Domain Ana							
-	-	Note: Answe	er any 2 quest	tions, each ca	arry equal	marks.		Marks	СО	Level
1	а	Discuss on st	tability of syst	em.				2	CO5	L2
	b	Obtain respo	nse equation	for a first or	ler mechan	ical syster	n subjected to unit s	tep 4	CO5	L2
		input.								
	c	Sketch Root	Locus plot f	or the unity	feedback	system wh	ose open loop trans	fer 3	CO6	L4
		function on s	tability of sys	tem.						
2	а	Sketch Root	Locus plot f	or the unity	feedback	system wh	ose open loop trans	fer 3	CO6	L4
		function on s	tability of sys	tem.						
	b	Discuss the V	Value of K for	phase margin	1			2	CO5	L2
	с	Discuss the V	Value of K for	gain margin				2	CO5	L2
3	а	Discuss the g	gain and phase	margin.				2	CO7	L2
	b	Plot the Nyq	uit diagram fo	r the open loo	op transfer	function.		5	CO8	L4

4	a	Discuss the gain and phase margin.	2	CO7	L2
	b	Sketch the bode plot for a unity feed-back system, whose open loop transfer	5	CO8	L4
		function.			

## b. Assignment – 2

Note: A distinct assignment to be assigned to each student.

				Mod	del Assignment Q	uestion:	8				
Crs Co	ode:	15ME73	Sem:	VII	Marks:		5 / 10 T	ime:	90 − 120 n	ninutes	
Course	e:	Steady s	state opera	tion,Transient	Response,Root	Locus					
		Plots,Free	luency Don	nain Analysis:							
Note:	Each	student to	answer 2-3	assignments. Ea	ach assignment ca	rries eq	ual mark	•			
SNo		USN		As	signment Descrij	otion			Marks	CO	Level
1			Obtain resp	ponse equation	for a first order n	nechani	cal system	m subjecte	d 5	CO5	L3
			to unit step	input.							
2			Define the	following terms	s:				5	CO5	L3
			ii) Delay ti	me							
			i) Rise time	e							
			iv)Maximu	ım overshoot							
			iii) Settling	g time							
3			Discuss on	stability of syst	tem.				5	CO5	L3
4			Obtain resp	ponse equation	for a first order n	nechani	cal system	m subjecte	d 5	CO5	L3
			to unit step	input.							
5			Discuss the	e Value of K for	phase margin				5	CO6	L4
6			Discuss the	e Value of K for	gain margin				5	CO6	L4
7			Explain the	effect of addit	ion of poles and z	ero's to	the syste	em	5	CO5	L3
8			Discuss the	e Limiting value	e of K for system	to be sta	able.		5	CO6	L4
9			Explain Ro	outh Hurwitz cri	iterion for stability	y of a co	ontrol sys	stem	5	CO5	L3
10			Obtain resp	ponse equation	for a first order n	nechani	cal system	m subjecte	d 5	CO5	L3
			to unit step	input.							
11			Sketch Roo	ot Locus plot fo	or the unity feedba	ick syst	em whos	e open loo	p 5	CO6	L4
			transfer fu	nction on stabili	ty of system.						
12			Sketch Roo	ot Locus plot fo	or the unity feedba	ick syst	em whos	e open loo	p 5	CO6	L4
			transfer fu	iction on stabili	ity of system.				_	~~ .	
13			Sketch Roo	ot Locus plot fo	or the unity feedba	ick syst	em whos	e open loo	p 5	CO6	L4
1.4			transfer fui	iction on stabili	ity of system.	1 /	1	1	~	001	T. 4
14			Sketch Roo	ot Locus plot fo	or the unity feedba	ick syst	em whos	e open loo	p 5	C06	L4
15			transfer fui	1Ction on stabili	ity of system.	-14		1	- 5	<u> </u>	T 4
15			Sketch Roo	ot Locus plot lo	or the unity leedba	ick syst	em wnos	e open 100	p 5	000	L4
16			Skotoh Dor	t Logue plot fo	ity of system.	al and	om who	a onan loo	n 5	C06	I.A
10			transfer fu	n Locus plot lo	ity of system	ick syst	em whos	e open 100	p J	000	L/ <del>1</del>
17			Discuss on	stability of sys	tom				5	C06	I.A
18			Obtain rest	ponse equation	for a first order n	hechani	cal system	m subjecte	d 5	C06	L4 L4
10			to unit ster	input	for a first order in	loonam	cai syste	in subjecte	u J	000	LT
19			Discuss the	- Value of K for	nhase margin				5	C06	Ι4
20			Discuss the	Value of K for	· gain margin				5	CO6	I 4
20			Sketch Roo	ot Locus plot fo	or the unity feedby	ck syst	em whos	e onen loo	n 5	C06	I 4
21			transfer fu	nction on stabili	ty of system	ick syst	ciii wiios	e open ioo	P J	000	LT
22			Sketch Roc	ot Locus plot fo	or the unity feedba	ck syst	em whos	e open loo	n 5	C06	Ι4
			transfer fu	iction on stabili	ity of system.	ien syst	<b>e</b> m whos	e open ioo	P	000	2.
23			Sketch Roo	ot Locus plot fo	or the unity feedba	ick syst	em whos	e open loo	p 5	CO6	L4
			transfer fu	nction on stabili	ity of system.			. r 100	-		
24			Sketch Roo	ot Locus plot fo	or the unity feedba	ick syst	em whos	e open loo	p 5	CO6	L4
			transfer fur	nction on stabili	ty of system.			1	•		
25			Sketch Roo	ot Locus plot fo	or the unity feedba	ick syst	em whos	e open loo	p 5	CO6	L4
			transfer fur	nction on stabili	ty of system.			1	•		
26			Sketch Roo	ot Locus plot fo	or the unity feedba	ick syst	em whos	e open loo	p 5	CO6	L4
			transfer fur	nction on stabili	ity of system.	-		-	-		

27	Sketch the root locus plot for the system whose open loop transfer function	5	CO6	L4
28	Sketch the root locus plot for the system whose open loop transfer function	5	CO6	L4
29	Sketch the root lSketch Root Locus plot for the unity feedback system whose open loop transfer function on stability of system.Sketch Root Locus plot for the unity feedback system whose open loop transfer function on stability of system.Obtain response equation for a first order mechanical system subjected to unit step input.Explain Routh Hurwitz criterion for stability of a control systemDiscuss the Limiting value of K for system to be stable.Explain the effect of addition of poles and zero's to the systemDiscuss the Value of K for gain margin Discuss the Value of K for phase marginObtain response equation for a first order mechanical system subjected to unit step input.Discuss on stability of system.Define the following terms: ii) Delay time i) Rise time iv)Maximum overshoot iii) Settling timeObtain response equation for a first order mechanical system subjected to unit step input.Sketch Root Locus plot for the unity feedback system whose open loop transfer function on stability of system ocus plot for the system whose open loop transfer function	5	CO6	L4
30	Sketch the root locus plot for the system whose open loop transfer function	5	CO6	L4
31	Explain the following: i) Lead compensator ii) Lag compensator	5	CO6	L3
32	Discuss the Value of K for phase margin	5	CO7	L4
33	Sketch the bode plot for a unity feed-back system, whose open loop transfer function	5	CO7	L4
34	Sketch the bode plot for a unity feed-back system, whose open loop transfer function	5	CO8	L4
35	Discuss the gain and phase cross over frequencies.	5	CO7	L4
36	Discuss the gain and phase margin.	5	CO8	L4
37	Discuss the stability of the closed loop system.	5	CO8	L4
38	Sketch the bode plot for a unity feed-back system whose open loop	5	C07	14
30	transfer function	5	C07	
40	transfer function		C07	
40	transfer function		07	L4
41	transfer function	5	07	L4
42	Plot the Nyquit diagram for the open loop transfer function	5	CO8	L4
43	Plot the Nyquit diagram for the open loop transfer function	5	CO8	L4
44	Plot the Nyquit diagram for the open loop transfer function	5	CO8	L4
45	Plot the Nyquit diagram for the open loop transfer function	5	CO8	L4
46	Plot the Nyquit diagram for the open loop transfer function	5	CO8	L4
47	Plot the Nyquit diagram for the open loop transfer function	5	CO8	L4
48	Plot the Nyquit diagram for the open loop transfer function	5	CO8	L4
49	Plot the Nyquit diagram for the open loop transfer function	5	CO8	L4
50	Plot the Nyquit diagram for the open loop transfer function	5	CO8	L4
51	Plot the Nyquit diagram for the open loop transfer function	5	CO8	L4
52	Plot the Nyquit diagram for the open loop transfer function	5	CO8	L4
53	Sketch the bode plot for a unity feed-back system, whose open loop transfer function	5	CO7	L4
54	Sketch the bode plot for a unity feed-back system, whose open loop transfer function	5	CO7	L4
55	Sketch the bode plot for a unity feed-back system, whose open loop transfer function	5	CO7	L4
56	Sketch the bode plot for a unity feed-back system, whose open loop transfer function	5	CO7	L4

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57	Sketch the bode plot for a unity feed-back system, whose open loop	5	CO7	L4
	transfer function			
58	Sketch the bode plot for a unity feed-back system, whose open loop	5	CO7	L4
	transfer function			
59	Sketch the bode plot for a unity feed-back system, whose open loop	5	CO7	L4
	transfer function			
60	Sketch the bode plot for a unity feed-back system, whose open loop	5	CO7	L4
	transfer function			
61	Sketch the bode plot for a unity feed-back system, whose open loop	5	CO7	L4
	transfer function			

# **D3. TEACHING PLAN - 3**

### Module – 5

Title:	System Compensation and State Variable Characteristics of Linear Systems	Appr	7 Hrs
		Time:	
a	Course Outcomes	-	Blooms
-	The student should be able to:	-	Level
1	state equations to study the controllability and observability	CO9	L2
2	Different system Compensators and variable characteristics of	CO10	L3
	linear systems.		
b	Course Schedule		
Class No	Module Content Covered	CO	Level
1	Series and feedback compensation,	CO9	L2
2	Introduction to state concepts, state equation of linear continuous data system	CO9	L2
3	Matrix representation of state equations,	CO9	L2
4	Controllability and observability	CO10	L3
5	Kalman and Gilberts test	CO10	L3
6	Problems	CO10	L3
7	problems	CO10	L3
	A		
с	Application Areas	CO	Level
1	Multiple system application,	CO9	L2
2	multivariable systems	CO10	L3
d	Review Questions	-	-
1	Explain the series with block diagrams	CO9	L2
2	A system is represented by a differential equation $y + 6y + 12y + 10y = 4U$ , where y	CO9	L2
	is the output and U is the input of the system. Obtain state space equation.		
3	A system is represented by a differential equation, where y is the output and U is the	CO10	L3
	input of the system. Obtain state space equation.		
4	Explain the effect of addition of poles and zero's to the system.	CO9	L2
5	Explain Kalman and Gilberts test	CO9	L2
6	Discuss the Controllability and observability	CO9	L2
7	Explain the feedback compensated system, with block diagrams	CO9	L2
8	A system is represented by a differential equation, where y is the output and U is the	CO10	L3
	input of the system. Obtain state space equation.		
9	A system is represented by a differential equation, where y is the output and U is the	CO10	L3
10	input of the system. Obtain state space equation.		
10	A system is represented by a differential equation, where y is the output and U is the input of the system. Obtain state space equation	CO10	L3
11	A system is represented by a differential equation, where y is the output and U is the	CO10	13
11	input of the system. Obtain state space equation.	010	LJ
12	A system is represented by a differential equation, where y is the output and U is the	CO10	L3
	input of the system. Obtain state space equation.		
13	A system is represented by a differential equation, where y is the output and U is the	CO10	L3
	input of the system. Obtain state space equation.		
14	A system is represented by a differential equation, where y is the output and U is the	CO10	L3
	input of the system. Obtain state space equation.		

15	A system is represented by a differential equation, where y is the output and U is the	CO10	L3
	input of the system. Obtain state space equation.		
16	A system is represented by a differential equation, where y is the output and U is the	CO10	L3
	input of the system. Obtain state space equation.		
17	A system is represented by a differential equation, where y is the output and U is the	CO10	L3
	input of the system. Obtain state space equation.		
18	A system is represented by a differential equation, where y is the output and U is the	CO10	L3
	input of the system. Obtain state space equation.		
19	A system is represented by a differential equation, where y is the output and U is the	CO10	L3
	input of the system. Obtain state space equation.		
20	A system is represented by a differential equation, where y is the output and U is the	CO10	L3
	input of the system. Obtain state space equation.		
e	Experiences	-	-
1		CO10	L2
2			
3			
4		CO9	L3
5			

# E3. CIA EXAM – 3

## a. Model Question Paper - 3

Crs Code: 15ME73 Sem: VII Marks: 15 Time: 75 minutes										
Cours	se:	System Compensation and State Variable Characteristics of Linear Systems								
-	-	Note: Answ	ver any 2	questions, eac	h carry equal	marks.		Marks	CO	Level
1	а	Explain the	series with	th block diagra	ams			2	CO9	L2
	b	A system is	represent	ed by a differe	ential equation	y + 6y + 12y	+10y = 4U, where	y 3	CO10	L3
		is the outpu	t and U is	the input of th	e system. Obtai	in state space	e equation.			
	с	Explain the	feedback	compensated	system, with bl	ock diagram	15	2	CO9	L2
2	а	a A system is represented by a differential equation, where y is the output and U is the				ne 3	CO10	L3		
		input of the	put of the system. Obtain state space equation.							
	b	Explain the effect of addition of poles and zero's to the system.					2	CO9	L2	
	с	A system is represented by a differential equation, where y is the output and U is th						ne 2	CO10	L3
		input of the	system. O	btain state spa	ce equation.					
3	а	Explain Kal	man test.					2	CO9	L2
	b	Discuss the	Controlla	bility.				2	CO9	L2
	с	A system is	represente	ed by a differe	ntial equation,	where y is th	ne output and U is the	ne 4	CO10	L3
		input of the	system. O	btain state spa	ce equation.					
4	а	Explain Gil	berts test					2	CO9	L2
$  \top$	b	A system is	represente	ed by a differe	ntial equation,	where y is the	ne output and $\overline{U}$ is the	ne 4	CO10	L3
		input of the	input of the system. Obtain state space equation.							
	c	Discuss the	observabi	lity				2	CO9	L2

### b. Assignment – 3

Note: A distinct assignment to be assigned to each student.

	Model Assignment Questions									
Crs Co	ode: 17ME73	Sem:	VII	Mar	ks:	5 / 10	Time: 9	90 – 120 minutes		
Course	e: System	Compensation	and	State	Variable					
	Character	istics of Linear	Systems							
Note: 1	Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.									
			Assignment Description							
SNo	USN		1	Assignme	nt Descr	iption		Marks	СО	Level
<b>SNo</b> 1	USN	Explain the seri	ies with	Assignme block dia	e <b>nt Descr</b> grams	iption		Marks 5	<b>CO</b> CO9	Level
<b>SNo</b> 1 2	USN	Explain the ser A system is rep	ies with presented	Assignme block dia l by a diff	e <b>nt Descr</b> grams Ferential e	<b>iption</b> equation y	+ 6y +12y +10y =	Marks           5           5	CO CO9 CO9	Level L2 L2
<b>SNo</b> 1 2	USN	Explain the ser A system is rep 4U , where y is	ies with presented the outp	Assignme block dia l by a diff out and U	ent Descr grams ferential e is the inp	<b>iption</b> equation yout of the s	+ 6y +12y +10y = system. Obtain state	Marks           5           5	CO9 CO9 CO9	Level L2 L2

3	A system is represented by a differential equation, where y is the output	5	CO10	L3
	and U is the input of the system. Obtain state space equation.			l
4	Explain the effect of addition of poles and zero's to the system.	5	CO9	L2
5	Explain Kalman and Gilberts test	5	CO9	L2
6	Discuss the Controllability and observability	5	CO9	L2
7	Explain the feedback compensated system, with block diagrams	5	CO9	L2
8	A system is represented by a differential equation, where y is the output	5	CO10	L3
	and U is the input of the system. Obtain state space equation.			l
9	A system is represented by a differential equation, where y is the output	5	CO10	L3
	and U is the input of the system. Obtain state space equation.			l
10	A system is represented by a differential equation, where y is the output	5	CO10	L3
	and U is the input of the system. Obtain state space equation.			l
11	A system is represented by a differential equation, where y is the output	5	CO10	L3
	and U is the input of the system. Obtain state space equation.			l
12	A system is represented by a differential equation, where y is the output	5	CO10	L3
	and U is the input of the system. Obtain state space equation.			l
13	A system is represented by a differential equation, where y is the output	5	CO10	L3
	and U is the input of the system. Obtain state space equation.			1
14	A system is represented by a differential equation, where y is the output	5	CO10	L3
	and U is the input of the system. Obtain state space equation.			1
15	A system is represented by a differential equation, where y is the output	5	CO10	L3
	and U is the input of the system. Obtain state space equation.			l
16	A system is represented by a differential equation, where y is the output	5	CO10	L3
	and U is the input of the system. Obtain state space equation.			l
17	A system is represented by a differential equation, where y is the output	5	CO10	L3
	and U is the input of the system. Obtain state space equation.			
18	A system is represented by a differential equation, where y is the output	5	CO10	L3
	and U is the input of the system. Obtain state space equation.			l
19	A system is represented by a differential equation, where y is the output	5	CO10	L3
	and U is the input of the system. Obtain state space equation.			L
20	A system is represented by a differential equation, where y is the output	5	CO10	L3
	and U is the input of the system. Obtain state space equation.			L

## F. EXAM PREPARATION

## 1. University Model Question Paper

Course:		Control engineering				Month /	Year	AUG /2	2019
Crs C	Code:	17ME73 Sem:	VII	Marks:	80	Time:		180 mi	nutes
-	Note	Answer all FIVE full questions. A	All questions c	arry equal m	arks.		Marks	CO	Level
1	a	Define control system with an exa	amples				3	CO1	L1
	b	Explain the concept of automatic	controls, with	examples			2	CO1	L2
	c	Explain in detail Proportional Inte	egral Differen	tial controlle	ers.		2	CO1	L3
			OR						
-	a	Explain in detail Proportional Dif		3	CO1	L2			
	b	Explain requirements of an ideal control system.						CO1	L4
	c	Explain in detail proportional integral, proportional differential controllers.						CO1	L3
2	a	Write the differential equations go	overning the b	ehaviour of	the mechanical	system.	4	CO2	L3
	b	obtain the analogous electrical equations	circuit based	on force ve	oltage analogy	and loop	2	CO2	L3
	с	obtain the analogous electrical circuit based on force voltage analogy and loop equations						CO2	L3
			OR						
-	a	obtain differential equations for the equivalent force-voltage and force	he mechanical	system show	wn. Also draw alogues quantitie	es.	4	CO2	L3
	b	liquid level system in which q, resistance, C is hydraulic capac function.	is inflow rate citance and h	e, qo is out f n is head of	flow rate, R is f liquid. Obtair	hydraulic transfer	2	CO2	L3
	c	Obtain differential equation for R	LC circuit.				2	CO2	L2

3	а	Discuss on stability of system.	2	CO5	L2
	b	Obtain response equation for a first order mechanical system subjected to unit step input.	4	CO5	L2
	с	Sketch Root Locus plot for the unity feedback system whose open loop transfer function on stability of system.	3	CO6	L4
		OR			
-	а	Sketch Root Locus plot for the unity feedback system whose open loop transfer function on stability of system.	3	CO6	L4
	b	Discuss the Value of K for phase margin	2	CO5	L2
	с	Discuss the Value of K for gain margin	2	CO5	L2
4	а	Discuss the gain and phase margin.	2	CO7	L2
	b	Plot the Nyquit diagram for the open loop transfer function.	5	CO8	L4
		OR	2	CO7	L2
-	a	Discuss the gain and phase margin.	5	CO8	L4
	b	Sketch the bode plot for a unity feed-back system, whose open loop transfer function.		CO8	
5	a	Explain the series with block diagrams	2	CO9	L2
	b	A system is represented by a differential equation $y + 6y + 12y + 10y = 4U$ , where y is the output and U is the input of the system. Obtain state space equation.	3	CO10	L3
	с	Explain the feedback compensated system, with block diagrams	2	CO9	L2
		OR			
	а	A system is represented by a differential equation, where y is the output and U is the input of the system. Obtain state space equation	3	CO10	L3
	h	Exploin the effect of addition of poles and zero's to the system	2	COD	1.2
	0	Explain the effect of addition of poles and zero's to the system.	2	C010	
	C	input of the system. Obtain state space equation.	L	010	LJ

### 2. SEE Important Questions

Course:		Control engineering	Month /	Year	Aug /20	)19
Crs C	Code:	17ME73 Sem: VII Marks: 80	Time:		180 mii	nutes
	Note	Answer all FIVE full questions. All questions carry equal marks.		-	-	
Mod	Qno.	Important Question		Marks	СО	Year
ule						
1	1	Define control system with an examples		2	CO1	2013
	2	Explain the concept of automatic controls with examples		4	CO1	2014
	3	Explain the concepts of feedback with examples		3	CO1	2015
	4	Explain requirements of an ideal control system.	5	CO1	2016	
	5	Write the different types of controllers.		6	CO2	2017
	6	Explain in detail proportional integral, proportional differential control	llers.	6	CO2	2015
	7	Explain in detail Proportional Differential controllers		6	CO2	2016
	8	Explain in detail Proportional Integral Differential controllers.		6	CO2	2017
2	1	obtain differential equations for the mechanical system shown. Also da	raw	7	CO3	2013
		equivalent force-voltage and force-current circuits using analogues qu	antities.			
	2	liquid level system in which q, is inflow rate, qo is out flow rate,	R is hydraulic	7	CO4	2014
		resistance, C is hydraulic capacitance and h is head of liquid. C				
		function.				
	3	Obtain differential equation for RLC circuit.		4	CO3	2015
	4	Obtain closed loop transfer function of the block diagram shown in F	ig. using block	5	CO4	2016
		diagram reduction techniques				
	5	Draw signal flow graph for the system shown in Fig. and find using	g Mason's gain	17	CO4	2017
		formula.				
	6	Obtain the transfer function of field controlled DC motor		7	CO3	2015
	7	obtain the analogous electrical circuit based on force voltage ana	logy and loop	7	CO3	2016
		equations				
	8	fnd the transfer function by using Mason's gain formula for the sign	nal flow graph	7	CO4	2017
		shown in fig.				

	9	reduce the block diagram shown in Fig. and obtain the transfer function	7	CO3	2016
	10	fnd the transfer function by using Mason's gain formula for the signal flow graph shown in fig.	7	CO4	2017
3	1	Obtain response equation for a first order mechanical system subjected to unit step input.		CO5	2013
	2	Define the following terms:		CO5	2014
		ii) Delay time			
		i) Rise time			
		iv)Maximum overshoot			
		iii) Settling time			
	3	Discuss on stability of system.		CO5	2015
	4	Obtain response equation for a first order mechanical system subjected to unit step input.		CO5	2016
	5	Discuss the Value of K for phase margin		CO5	2017
	6	Discuss the Value of K for gain margin		CO5	2015
	7	Explain the effect of addition of poles and zero's to the system		CO5	2016
	8	Discuss the Limiting value of K for system to be stable.		CO5	2017
	9	Explain Routh Hurwitz criterion for stability of a control system		CO6	2016
	10	Sketch Root Locus plot for the unity feedback system whose open loop transfer function on stability of system.		CO6	2017
4	1	Discuss the Value of K for phase margin	2	C07	2016
4	1	Sketch the hode plot for a unity feed heak system, whose open loop transfer	12	C07	2010
	2	function	12	0.08	2017
	3	Plot the Nyquit diagram for the open loop transfer function	12	CO8	2016
	4	Discuss the gain and phase cross over frequencies.	4	CO8	2017
	5	Discuss the gain and phase margin.	4	CO7	2018
	6	Discuss the stability of the closed loop system.	4	CO7	2018
5	1	Explain the series with block diagrams	2	CO9	2014
	2	A system is represented by a differential equation $y + 6y + 12y + 10y = 4U$ , where y is the output and U is the input of the system. Obtain state space equation.	8	CO9	2015
	3	A system is represented by a differential equation, where y is the output and U is the	8	CO10	2016
	4	input of the system. Obtain state space equation.	0	C00	2017
	4	Explain the effect of addition of poles and zero's to the system.	8	C09	2017
	5	Explain Kalman and Giberts test	4	C09	2015
	0	Discuss the Controllability and observability	4	C09	2016
	/ 0	Explain the reedback compensated system, with block diagrams	4	C09	2017
	ð	input of the system. Obtain state space equation.	0	010	2016
	9	A system is represented by a differential equation, where y is the output and U is the	6	CO10	2017
	10	A system is represented by a differential existing where wis the system is the system is the system of the system	6	CO10	2010
	10	A system is represented by a differential equation, where y is the output and U is the input of the system. Obtain state space equation	0	010	2018
		input of the system. Obtain state space equation.			
1	1			1	i.

# G. Content to Course Outcomes

## **1. TLPA Parameters**

Table 1:	TLPA –	Example	Course

Mo	Course Content or Syllabus	Content	Blooms'	Final	Identified	Instructio	Assessment
dul	(Split module content into 2 parts which have	Teaching	Learning	Bloo	Action	n	Methods to
e- ‡	similar concepts)	Hours	Levels for	ms'	Verbs for	Methods	Measure
			Content	Level	Learning	for	Learning
						Learning	
Α	В	С	D	E	F	G	H
1	Introduction: Concept of automatic controls,	4	L1,L2	L2	Understan	Chalk	Assignment
	Open loop and closed loop systems,				d	and board	

	Concepts of feedback, requirements of an ideal control system, Types of controllers-Proportional, Integral, Differential, Proportional & Integral, Proportional Differential and Proportional Integral Differential controllers.						
1	Block diagram Algebra: General representation of a feedback control system, transfer functions, rules of block diagram algebra, reduction of block diagram to obtain closed loop transfer function. Signal flow graphs : Mason's gain formula	3	L1,L2,L3	L3	Apply	Chalk and board	Assignment
2	Steady state operation: Steady state analysis for general block diagram. for a control system, steady state characteristics, equilibrium in a system. Transient Response: Transient response and steady state analysis of unit, step input,	7	L1,L2,L3	L3	Apply	Chalk and board	Assignment and Slip Test
2	general operational representation for a differential equation of control system, distinct, repeated and complex conjugate zeros, general form of transient response, Routh's stability criterion for a control system.	6	L1,L2,L3	L3	Apply	Chalk and board	Assignment
3	Root Locus Plots : Root locus method: Significance of Root locus,	7	L1,L2,L3	L3	Apply	Chalk and board	Assignment and slip test
3	angle and magnitude conditions, breakaway points, angles of departure and arrival, construction of Root locus using general rules and steps, Lead and Lag compensation	7	L1,L2	L2	Understan d	Chalk and board	Assignment
4	Frequency Domain Analysis: Relationship between time and frequency response, Polar plot, Bode's Plot,	7	L1,L2,L3	L3	Apply	Chalk and board	Assignment
4	Nyquist plot and Nyquist stability criterion, Relative Stability, Phase and Gain Margins	7	L1,L2,L3	L3	Apply	Chalk and board	Assignment
5	System Compensation and State Variable Character- istics of Linear Systems :Series and feedback com- pensation, Introduction to state concepts,	4	L1,L2	L2	Understan d	Chalk and board	Assignment
5	state equation of linear continuous data system. Matrix representation of state equations, controllability and observability, Kalman and Gilberts test	3	L1,L2	L2	understand	Chalk and board	Assignment

### 2. Concepts and Outcomes:

#### Table 2: Concept to Outcome – Example Course

Mo	Learning or	Identified	Final Concept	<b>Concept Justification</b>	CO Components	Course Outcome
dul	Outcome from	Concepts		(What all Learning	(1.Action Verb,	
e- #	study of the	from		Happened from the	2.Knowledge,	
	Content or	Content		study of Content /	3.Condition /	Student Should be
	Syllabus			Syllabus. A short word	Methodology,	able to
				for learning or	4.Benchmark)	
				outcome)		
Α	Ι	J	K	L	М	N
1	Introduction:	Control,	Control,	Different types of	- Understand	Understand Control,
	Concept of	feedback,	feedback,	methods	- conversion	feedback, controllers
	automatic	controllers	controllers		methodology	
	aantrola				-	
1	controls,					

	, · · ·		I.	1	1	
	Open loop				-	
	and closed					
	loop					
	systems,					
	Concepts of					
	feedback,					
	requirements					
	of an ideal					
	control					
	system,					
	Types of					
	controllers-					
	Proportional,					
	Integral,					
	Differential, Proportional &					
	Integral					
	Proportional					
	Differential and					
	Proportional					
	Integral					
	Differential					
1	controllers.	Math	Mathanatian1	W/a alain a main ain al	TT- d d	A
1	Algebra	al Model	Model block	working principal	- Onderstand	Apprying the
	General	block and	and signal		methodology	Mathematical Model.
	representation	signal	diagram		-	block and signal
	of a feedback	diagram	8		-	υ
	control system,	-				
	transfer					
	functions, rules					
	of block					
	alagram					
	reduction of					
	block diagram					
	to obtain closed					
	loop transfer					
	function. Signal					
	flow graphs :					
	Mason's gain					
2	Iomuua Steady state	Analysis of	Analysis of a	Different system	Understand	Analysis of a system
2	operation:	a system	system	Different system	- conversion	r marysis of a system
	Steady state		~		methodology	
	analysis for					
	general block					
	diagram. for a					
	control system,					
	steady state					
	equilibrium in a					
	system.					
	Transient					
	Response:					
	Transient					
	response and					
	steady state					
	analysis of unit,					
	step input,		1	1	1	

<sup>2</sup> general operational	stability analysis	stability analysis	stability analysis	-Understand - conversion methodology	Applying knowledge analysis	the stability
n for a				-		
differential						
antierential						
equation of						
control						
system,						
distinct,						
repeated and						
complex						
conjugate						
zeros,						
general form						
of transient						
response,						
Routh's						
stability						
criterion for						
a control						
system.		. 1 .1.	. 1		A 1 1	.1
3 Root Locus	sstability	stability	stability analysis	Understand	Applying	the
locus method	:	anarysis		- conversion	analysis	stability
Significance of	f				unur joro	
Root locus,						
4 angle and mag	-stability	stability	stability analy		Applying	the
nitude condi	-analysis	analysisstabilit		- Understand	knowledge	stability
tions, breaka	-	y analysis		- conversion	analysis	
angles of depar	, 			-		
ture and arrival	,					
construction of	f					
Root locus us	-					
ing genera	1					
Lead and Las	, ,					
compensation						
4 Frequency	stability	stability	stability analysis	- Understand	Applying	the
Domain	analysis	analysis		- conversion	knowledge	stability
Analysis:				methodology	analysis	
between time	<b>_</b>					
and frequency	7					
response, Pola	r					
plot, Bode's	5					
Plot,	4.4.1.1114	1. 11 .		TT. 1	A	.1
5 Nyquist plo	tstability	stability	stability analysis	- Understand	Applying knowledge	the
stability criteri	-	v analysisstatill		methodology	analysis	stability
on, Relative	e	, anar, 616		linethousing	unur y 510	
Stability, Phase	e					
and Gain Mar	-					
gins				<b>TT 1</b>	A 1 '	.1
bystem Com	-transient	uransient and	istate time response	Understand	Applying knowledge	the
State Variable	estate tim	etime response		- conversion methodology	and steady	aunstein

Characteristics of Linear Sys- tems :Series and feedback compensation, Introduction to state concepts,	response				
state equation of linear continuous data system. Matrix representatio n of state equations, controllabilit y and observability , Kalman and Gilberts test	transient and steady state time response	transient and steady state time response	state time response	Understand - conversion methodology	Applying the knowledge state time response