FR. Conceicao Rodrigues College Of Engineering

Father Agnel Ashram, Bandstand, Bandra-west, Mumbai-50

Department of Electronics Engineering

Lecture Plan:

Subject: LINEAR CONTROL SYSTEMS (LCS-ELX406) **Credits-4**

S.E. (ELECTRONICS) (semester IV) (2018-2019)

1. SYLLABUS

Programme Structure for Bachelor of Engineering (B.E.) – Electronics Engineering (Rev. 2016)

Module No.	Topics	Hrs.
1	**Models for Control System**	08
	1.1 Introduction: Open loop and closed loop systems; feedback and feed-forward control structure; examples of control systems.	
	1.2 Mathematical Modelling: Types of models; Impulse response model; State Variable model and Transfer function model for Electrical, Mechanical and Thermal systems	
	1.3 Manipulations: Block Diagram Representation of complex systems, Block diagram reduction, Signal flow graph and the Mason's gain rule for determining overall transfer function of Single Input, Single output systems	
2	**Time Response Analysis**	08
	2.1 Dynamic Response: Standard test signals; Transient and steady state behaviour of first and second order systems	
	2.2. Performance Specifications for a second order system and derivations for rise time, settling time, peak time, peak overshoot and steady state error	
	2.3. Steady State errors in feedbackcontrol systems and their types, Error constants and type of system.	
3	**State Variable Models**	10
	3.1 State variable models: State variable models of electrical systems	
	3.2 State transition equation: Concept of state transition matrix; Properties of state transition matrix; Solution of homogeneous systems; solution of nonhomogeneous systems.	
	3.3 Controllability and Observability: Concept of controllability; Controllability analysis of LTI systems; Concept of observability; Observability analysis of LTI systems using Kalman approach.	
4	**Stability Analysis in Time Domain**	06
	4.1 Concepts of Stability: Concept of absolute, relative and robust stability; Routh stability criterion.	
	4.2 Root Locus Analysis: Root-locus concepts; General rules for constructing root-locus; Root-locus analysis of control systems.	
5	**Stability Analysis in Frequency Domain**	10
	5.1 Introduction: Frequency domain specifications, Response peak and peak resonating frequency; Relationship between time and frequency domain specifications of system; Stability margins.	
	5.2 Bode plot: Magnitude and phase plot; Method of plotting Bode plot; Stability margins on the Bode plots; Stability analysis using Bode plot.	
	5.3 Nyquist Criterion: Polar plots, Nyquist stability criterions; Nyquist plot; Gain and phase margins.	
6	**Compensators and Controllers**	06
	6.1 Compensators: Types of compensation; Need of compensation; Lag compensator; Lead compensator.	
	6.2 Controllers: Concept of ON/OFF controllers; Concept of P, PI, PD and PID Controllers.	
	6.3 Advances in Control Systems: Introduction to Robust Control, Adaptive Control and Model Predictive control.	
	Total	**48**

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2. Course Outcomes:

Upon completion of this course students will be able to:

EXC404.1: Differentiate between open loop, close loop and feed forward control systems.
EXC404.2: Model simple electrical, mechanical and thermal systems using transfer function and state space method.
EXC404.3: Describe and derive time domain and frequency domain specifications of linear systems.
EXC404.4: Analyze system stability using time domain and frequency domain techniques.
EXC404.5: Explain types of compensator and PID controller.

3. Relationship of course outcomes with program outcomes: Indicate 1 (low importance), 2 (Moderate Importance) or 3 (High Importance) in respective mapping cell.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**
EXC404.1	3													
EXC404.2	3	*3*												
EXC404.3	3	3												
EXC404.4	3	3												
EXC404.5	3													
Course Average	3	3												

4. CO Assessment Tools:

Course Outcome	***Assessment Method***					
	Direct Method (80 %)					***Indirect Method (20%)***
	Unit Tests		Assignments	Tutorials	Semester End Examination	Course exit survey
	1	2	-			
EXC404.1	30%		-	20%	50%	100%
EXC404.2	30%		-	20%	50%	100%
EXC404.3	30%		-	20%	50%	100%
EXC404.4		30%	-	20%	50%	100%

EXC404.5		30%		20%	50%	100%

5. Curriculum Gap/Content beyond syllabus (if any).

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6. Lecture Plan.

CLASS		SE Electronics, Semester IV	
Academic Term		January – May 2019	
Subject		**Linear Control Systems (ELX 406)**	
Periods (Hours) per week	***Lecture***	4	
	Practical	--	
	Tutorial	--	
Evaluation System		***Hours***	***Marks***
	Theory examination	3	80
	Internal Assessment	--	20
	Practical Examination	--	--
	Oral Examination	--	--
	Term work	--	--
	Total	--	100

Time Table	***Day***	***Time***
	Tuesday	09.45 am – 10.45 am
	Wednesday	01.30 pm – 02.30 pm
	Thursday	11.00 am – 12.00 pm
	Friday	11.00 am – 12.00 pm

Course Content and Lesson plan

Module – 1 Introduction to control system analysis

Week	**Lecture No.**	**Date**		**Topic**	**Remarks(If any)**
		Planned	**Actual**		
1	1	02 – 01 – 19		Discussion of syllabus and COs	
	2	03 – 01 – 19		Open loop control system, close loop control system, examples of open loop closed loop systems	Special Time Table

	3	04 – 01 – 19		Open loop control system, close loop control system, examples of open loop closed loop systems	
Module - 2 Mathematical Modeling of Systems					
Week	**Lecture No.**	**Date**		**Topic**	**Remarks(If any)**
		Planned	**Actual**		
2	4	08 – 01 – 19	08 – 01 – 19	Mathematical modeling of the system, Modeling of Mechanical systems, Modeling of electrical system using transfer function model	Special Time Table
	5	09 – 01 – 19	09 – 01 – 19	Mathematical modeling of the system, Modeling of Mechanical systems, Modeling of electrical system using transfer function model	
	6	10 – 01 – 19	10 – 01 – 19	Block reduction technique.	
	7	11 – 01 – 19	11 – 01 – 19	Block reduction technique.	
3	8	15 – 01 – 19	15 – 01 – 19	Signal flow graph, Masons gain formula, problems based on SFG.	
	9	16 – 01 – 19	16 – 01 – 19	Problems based on SFG.	
	10	17 – 01 – 19	17 – 01 – 19	Standard test signals, Impulse response model,	
	11	18 – 01 – 19	18 – 01 – 19	Type of a system, Steady state error analysis	
4	12	22 – 01 – 19	22 – 01 – 19	Type of a system, Steady state error analysis	
	13	23– 01 – 19	23– 01 – 19	Transient Analysis of second order system for step input. Time domain specifications of systems.	
	14	24 – 01 – 19	24 – 01 – 19	Transient Analysis of second order system for step input. Time domain specifications of systems.	
	15	25 – 01 – 19	25 – 01 – 19	Numerical Examples	
Module – 4 Stability Analysis in Time Domain					
Week	**Lecture No.**	**Date**		**Topic**	**Remarks(If any)**
		Planned	**Actual**		
5	16	29 – 01 – 19	29 – 01 – 19	Concept of stability, stability analysis using Routh's stability criterion.	
	17	30 – 01 – 19	30 – 01 – 19	Stability analysis using Routh's stability criterion.	
		31 – 01 – 19			Annual Sports Day
	18	01 – 02 – 19	01 – 02 – 19	Root locus concept, Rules for constructing root locus.	

Module – 5 Stability analysis in frequency domain					
Week	**Lecture No.**	**Date**		**Topics**	**Remarks (If Any)**
		Planned	**Actual**		
6		05 – 02 – 19			Unit Test 1
		06 – 02 – 19			
	19	07 – 02 – 19	07 – 02 – 19	Root locus analysis of control systems	
	20	08 – 02 – 19	08 – 02 – 19	Root locus analysis of control systems	
7	21	12 – 02 – 19	12 – 02 – 19	Root locus analysis of control systems	
		13 – 02 – 19			Cultural week
		14 – 02 – 19			
		15– 02 – 19			
8		19 – 02 – 19			Holiday Shivaji Jayanti
	22	20 – 02 – 19	20 – 02 – 19	Frequency domain specifications. Relationship between time and frequency domain specification of system.	
	23	21 – 02 – 19	21 – 02 – 19	Bode plots , gain margin phase margin, stability analysis based on Bode plot .	
	24	22 – 02 – 19	22 – 02 – 19	Stability analysis using bode plot.	
9	25	26 – 02 – 19	26 – 02 – 19	Stability analysis using bode plot.	
	26	27 – 02 – 19	27 – 02 – 19	Polar plot.	
	27	28 – 02 – 19	28 – 02 – 19	Nyquist stability criterion, Nyquist plot.	
	28	01 – 03 – 19	01 – 03 – 19	Nyquist plot.	
Module – 3 State Variable Models					
Week	**Lecture No.**	**Date**		**Topic**	**Remarks(If any)**
		Planned	**Actual**		
10	29	05 – 03 – 19	05 – 03 – 19	Examples for practice	
	30	06 – 03 – 19	06 – 03 – 19	State variable model, state variable model of electrical system,	
	31	07 – 03 – 19	07 – 03 – 19	State variable model of mechanical system. State variable model of thermal .	
		08 – 03 – 19	12 – 03 – 19	State transition matrix, properties of state transition matrix.	Adjusted by Prof. Heena
11	32	12 – 03 – 19	12 – 03 – 19	Problems based on state transition matrix.	

	33	13 – 03 – 19	13 – 03 – 19	Solution of homogeneous systems, solution of non homogeneous system.	
	34	14 – 03 – 19	14 – 03 – 19	Controllability, analysis of LTI system	
		15 – 03 – 19			Crescendo
Module – 6 Compensator and Controllers					
Week	**Lecture No.**	**Date**		**Topic**	**Remarks(If any)**
		Planned	**Actual**		
12	35	19 – 03 – 19	19 – 03 – 19	Observability, analysis of LTI system using kalman approach.	
	36	20 – 03 – 19	20 – 03 – 19	Compensator, Types of compensator, Need of compensators.	
		21 – 03 – 19			Holi
	37	22 – 03 – 19	22 – 03 – 19	Lead compensator, Lag compensator, Lead-Lag compensator.	
13	38	26 – 03 – 19	26 – 03 – 19	Lead compensator, Lag compensator, Lead- Lag compensator.	
	39	27 – 03 – 19	27 – 03 – 19	Concept of ON-OFF controllers , concept of Proportional Controller.	
	40	28 – 03 – 19	28 – 03 – 19	Concept of Integral controller, Derivative Controller, PID Controller.	
	41	29 – 03 – 19	29 – 03 – 19	Advances in control systems, Introduction to robust control.	
14	42	02 – 04 – 19	02 – 04 – 19	Concept of adaptive control, model predictive control.	
	43	03 – 04 – 19	03 – 04 – 19	Examples For Practice	
	44	04 – 04 – 19	04 – 04 – 19	Examples For Practice	
	45	05 – 04 – 19	05 – 04 – 19	Examples For Practice	
		09 – 04 – 19			Unit Test II
		10 – 04 – 19			
Total Number of Lectures				45	

Text Books:

1. I. J. Nagrath, M. Gopal, Control Systems Engineering, New Age International, Fifth Edition, 2012.
2. Dhanesh N. Manik, Control Systems, Cengage Learning, First Edition, 2012.
3. M. Gopal, Control Systems: Principle and design, Tata McGraw Hill, First Edition, 1998
4. Richard C. Dorf and Robert H. Bishop, Modern Control System, Pearson, Eleventh Edition, 2013.

5. Norman S. Nice, Control Systems Engineering, John Wiley and Sons, Fifth Edition, 2010
6. Rajeev Gupta, Control Systems Engineering, Wiley India, First Edition, 2011.

Internal Assessment: (IA):
Two tests must be conducted which should cover at least 80% of the syllabus. The average marks of both the test will be considered as final IA marks.

End Semester Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. The students need to solve total 4 questions.
3. Question No. 1 will be compulsory and based on entire syllabus.
4. Remaining question (Q.2 to Q.6) will be set from all the modules.
5. Weightage of marks will be as per Blueprint.