



INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE DESCRIPTOR

Course Title	ADVANCED CONTROL SYSTEMS				
Course Code	AEE527				
Programme	B.Tech				
Course Type	Professional Elective - III				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lectures	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Chief Coordinator	Ms. S Swathi, Assistant Professor, EEE				
Course Faculty	Ms. S Swathi, Assistant Professor, EEE				

I. COURSE OVERVIEW:

This course deals with introduces the fundamental concepts, principles and application of advanced control system analysis. This course includes state models for linear and continuous time systems, solution of state and output equation, controllability and observability, state observer design of control systems with observers and explains about features of linear and non linear systems. This subject describes the Describing function analysis of non-linear systems, Liapunov's stability, time varying optimal control of control systems.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AEE009	IV	Control systems	4

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Advanced Control Systems	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Chalk & Talk	✓	Quiz	✓	Assignments	✓	MOOCs
✓	LCD / PPT	✓	Seminars	✗	Mini Project	✗	Videos
✗	Open Ended Experiments						

V. EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE units and each unit carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with “either” or “choice” will be drawn from each unit. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

50 %	To test the objectiveness of the concept.
50 %	To test the analytical skill of the concept OR to test the application skill of the concept.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 25 marks for Continuous Internal Examination (CIE), 05 marks for Quiz/ Alternative Assessment Tool (AAT).

Table 1: Assessment pattern for CIA

Component	Theory		Total Marks
	CIE Exam	Quiz / AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz / Alternative Assessment Tool (AAT):

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Marks shall be awarded considering the average of two quizzes for every course. The AAT may include seminars, assignments, term paper, open ended experiments, five minutes video and MOOCs.

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (POs)		Strength	Proficiency assessed by
PO 1	Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Presentation on real-world problems
PO 2	Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	2	Seminar
PO 3	Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	3	Guest Lectures
PO4	Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	3	Seminar

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSOs)		Strength	Proficiency assessed by
PSO 1	Problem Solving: Exploit the knowledge of high voltage engineering in collaboration with power systems in innovative, dynamic and challenging environment, for the research based team work.	2	Assignment and Seminar
PSO 2	Professional Skills: Identify the scientific theories, ideas, methodologies and the new cutting edge technologies in renewable energy engineering, and use this erudition in their professional development and gain sufficient competence to solve the current and future energy problems universally.	--	--
PSO 3	Modern Tools in Electrical Engineering: Comprehend the technologies like PLC, PMC, process controllers, transducers and HMI and design, install, test, maintain power systems and industrial applications.	--	--

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES (COs):

The course should enable the students to:	
I	Apply phase plane analysis to linear and non linear control systems
II	Analyze the stability of the systems using different techniques
III	Illustrate the design of optimal controller.
IV	Demonstrate state variable analysis, non-linear systems and optimal control.

IX. COURSE LEARNING OUTCOMES (CLOs):

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
AEE527.01	CLO 1	Define basic concepts of state, state variable and state model.	PO1,PO2, PSO1	3
AEE527.02	CLO 2	Explain the properties of linear and continues time systems such as controllability and observability.	PO1,PO2, PSO1	3
AEE527.03	CLO 3	Design of control systems with state observers.	PO1,PO2, PO3, PSO1	3
AEE527.04	CLO 4	Study the features of linear and non linear systems.	PO1	2
AEE527.05	CLO 5	Demonstrate non-linear system behavior by phase plane, isoclines method.	PO1,PO2, PSO1	3
AEE527.06	CLO 6	Derive the describing function for common non-linearities.	PO1,PO2, PSO1	2
AEE527.07	CLO 7	Analyze the describing function methods for non - linear systemss	PO1,PO2, PSO1	2
AEE527.08	CLO 8	Observe the condition for stability and stability Oscillations.	PO1,PO2, PO4	3
AEE527.09	CLO 9	Perform the stability analysis of nonlinear systems by Liapunov's' method	PO1,PO2, PO4,PSO1	3
AEE527.10	CLO 10	Develop and design skills in optimal control problems.	PO1,PO3, ,PSO1	3
AEE527.11	CLO 11	Learn the Lure's transformation, Aizerman's and Kalman's conjecture stability technique	PO1,PO2, PO4,PSO1	3
AEE527.12	CLO 12	Study the concept of Popov's criterion, Circle criterion.	PO1,PO2, PO4,PSO1	3
AEE527.13	CLO 13	Discuss the concept of decoupling.	PO1,PO2, PSO1	3
AEE527.14	CLO 14	Design the linear quadratic regulator for optimal control.	PO1,PO3, PSO1	3
AEE527.15	CLO 15	Study the concept of steady state optimal control, optimal estimation	PO1	2
AEE527.16	CLO 16	Design the multivariable control for optimal control.	PO1,PO3, PSO1	3
AEE527.17	CLO 17	Explore the knowledge and skills of employability to succeed in national and international level competitive examinations.	PO1,PO2, PO3,PSO1	2

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X. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

(CLOs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 1	2	3											3		
CLO 2	2	3											3		
CLO 3	2	2	3										2		

(CLOs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 4	2														
CLO 5	2	3											3		
CLO 6	2	2											2		
CLO 7	2	2											2		
CLO 8	2	2		3											
CLO 9	2	2		3									3		
CLO 10	2		3										2		
CLO 11	2	3		3									2		
CLO 12	2	3		3									2		
CLO 13	2	3											2		
CLO 14	2		3										2		
CLO 15	2														
CLO 16	2		3										2		
CLO 17	2	2	2										2		

3 = High; 2 = Medium; 1 = Low

XI. ASSESSMENT METHODOLOGIES – DIRECT:

CIE Exams	PO1,PO2, PO3,P04	SEE Exams	PO1, PO2, PO3, PO4	Assignments	PO1, PO2, PO3, P04	Seminars	PO1
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	-						

XII. ASSESSMENT METHODOLOGIES – INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
✗	Assessment of Mini Projects by Experts		

XIII. SYLLABUS:

UNIT-I	STATE VARIABLE ANALYSIS
Concept of state , state variable and state model, state models for linear and continuous time systems, solution of state and output equation, controllability and observability, pole placement, state observer design of control systems with observers.	

UNIT-II	PHASE PLANE ANALYSIS
Features of linear and non linear systems, common physical non-linearity's , methods of linearising non-linear systems, concept of phase portraits, singular points, limit cycles, construction of phase portraits, phase plane analysis of linear and non-linear systems, isoclines method.	
UNIT-III	DESCRIBING FUNCTION ANALYSIS
Basic concepts, derivation of describing functions for common non-linearities. Describing function analysis of non-linear systems, conditions for stability, Stability of oscillations.	
UNIT-IV	STABILITY ANALYSIS
Introduction, Liapunov's stability concept, Liapunov's direct method, Lure's transformation, Aizerman's and Kalman's conjecture, Popov's criterion, Circle criterion.	
UNIT-V	OPTIMAL CONTROL
Introduction, decoupling, time varying optimal control, linear quadratic regulator (LQR), steady state optimal control, optimal estimation, multivariable control design.	
Text Books:	
<ol style="list-style-type: none"> 1. M Gopal, "Modern control system theory", New Age International Publishers, 1st Edition, 2002. 2. Ashish Tewari, "Modern Control Design with MATLAB and Simulink", John Wiley, 2nd Edition, 2002. 	
Reference Books:	
<ol style="list-style-type: none"> 1. George J Thaler, "Automatic Control Systems", Jaico Publishers, 2nd Edition, . 2. I J Nagrath and M Gopal, 'Control Systems Engineering', New Age International Publishers, 1st Edition , 2003. 3. Gene F Franklin, J David Powell, Abbasemami-Naeini, "Feedback Control of Dynamic Systems", Pearson Education, 1st Edition 2002. 	

XIV. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
1	Define state, state space and state space model.	CLO1	T1:5.1
2	Concept of state models for linear and continuous time systems.	CLO1	T1:5.2
3	Derive the solution of state and output equations.	CLO1	T1:5.5
4	Define the concept of controllability.	CLO2	T1:6.2
5	Study the concept of observability.	CLO2	T1:6.3
6	Describe the concept of pole placement in control system.	CLO3	T2:5.3
7	Design of control systems with state observers	CLO3	T2:5.4
8-12	Tutorial problems	CLO1	T1:5.4
13	Study the features of linear and non linear systems.	CLO4	R1:2.1
14	Learn the common physical non-linearities.	CLO4	R1:2.3
15	Define the methods of linearizing non-linear systems.	CLO4	R1:2.6

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
16	Discuss concept of phase portraits, singular points and limit cycles.	CLO5	R1:2.9
17-19	Construct the phase portraits, phase plane analysis of linear and non-linear	CLO5	R1:2.10
20-22	Observe the phase plane analysis of linear and non-linear systems	CLO5	R1:2.10
23	Study the isoclines method for non-linear systems.	CLO5	R1:2.10
24-26	Tutorial problems.	CLO5	R1:2.11
27-28	Discuss basic concepts of describing functions for non-linearities.	CLO6	R1:2.6
29-30	Describing function analysis of non-linear systems.	CLO7	R1:2.7
31	Derive Conditions for stability in non-linear systems.	CLO8	R1:2.8
32	Observe Stability of oscillations for non-linear systems.	CLO8	R1:2.9
34-36	Tutorial problems.	CLO7	R1:2.9
37	Study the concept of Liapunov's stability.	CLO9	R1:8.5
38	Discuss the Liapunov's direct method.	CLO9	R1:8.6
39	Derive Lure's transformation.	CLO11	T1:11.1
40	Construct Aizerman's and Kalman's conjecture.	CLO12	T1:11.2
41	Study the circle criterion.	CLO12	T1:11.3
42-46	Tutorial problems.	CLO9	T1:11.4
47	Discuss the concept of decoupling.	CLO13	T1:11.5
48	Define time varying optimal control method.	CLO15	T1:12.3
49	Derive the concept of linear quadratic regulator.	CLO14	T1:12.5
50	Define the steady state optimal control technique.	CLO15	T1:12.6
51	Describe the concept of optimal estimation.	CLO15	T1:12.6
52	Design the multivibrator control for time varying systems.	CLO16	T1:12.7
53-60	Tutorial problems.	CLO15	T1:12.8

XV. GAPS IN THE SYLLABUS - TO MEET INDUSTRY / PROFESSION REQUIREMENTS:

S No	Description	Proposed actions	Relevance with POs	Relevance with PSOs
1	Checking controllability and observability of non-linear systems.	Matlab Demos	PO5	PSO3
2	Methods of Tuning in PID Controllers.	Seminars / NPTEL	PO1, PO3	PSO1

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