INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

ELECTRONICS AND COMMUNICATION ENGINEERING

COURSE DESCRIPTOR

Course Title	**CONTROL SYSTEMS**				
Course Code	AEE009				
Programme	B.Tech				
Semester	IV	ECE			
Course Type	Core				
Regulation	IARE - R16				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	-	-
Chief Coordinator	Dr. Kaul, Professor				
Course Faculty	Dr. K Nehru, Professor Mr. N Nagaraju, Assistant Professor Mr. M L RaviTeja, Assistant Professor				

I. COURSE OVERVIEW:

The course will make them learn the basic fundamentals of modeling and control of linear time invariant systems. Component modeling and servomechanisms which play major part in speed and position control systems. Starting from a problem statement they will learn to design a dynamic control system for a given specification. They will be able to analyze open loop and closed loop systems in time and frequency domains. They will learn to design different types of controllers and their simulation techniques using available software platforms.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AHS011	III	Mathematical Transform Techniques	4

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
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 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” are drawn from each unit of the syllabus. 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 theoretical concepts and derivation capabilities.
50 %	To test the analytical and problem solving skills.

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks of which 25 marks for problem solving and 05 marks for Quiz/ Alternative Assessment Tool (AAT).

Table 1: Assessment pattern for CIA

Component	**Theory**		**Total Marks**
Type of Assessment	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 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.	3	Lectures, Assignments
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.	2	Lectures, Assignments
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary Settings.	2	One minute videos
PO 12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2	Lectures

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSOs)		Strength	Proficiency assessed by
PSO 1	**Professional Skills:** The ability to understand the basic concepts in Electronics & Communication Engineering and to apply them to various areas, like Electronics, Communications, Signal processing, VLSI, Embedded systems etc., in the design and implementation of complex systems.	2	Seminars
PSO 2	**Problem-Solving Skills:** The ability to solve complex Electronics and communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.	-	-
PSO 3	**Successful Career and Entrepreneurship:** The understanding of social-awareness & environmental-wisdom along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an Entrepreneur.	-	-

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES (COs):

The course should enable the students to:	
I	Organize modelling and analysis of electrical and mechanical systems.
II	Evaluate systems by applying block diagrams, signal flow graphs to study the time response.
III	Demonstrate the analytical and graphical techniques to study the stability to design the control system.
IV	Illustrate the frequency domain and state space analysis.

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
AEE009.01	CLO 1	Understand the concept of open loop and closed loop systems with real time examples.	PO 1	3
AEE009.02	CLO 2	Derive the mathematical model for electrical and mechanical systems using differential equations.	PO 1	2
AEE009.03	CLO 3	Identify the equivalent model for electrical and mechanical systems using force voltage and force current analogy.	PO 1, PO 12	2
AEE009.04	CLO 4	Discuss the block diagram reduction techniques and effect of feedback in open loop and closed loop systems.	PO 3	3
AEE009.05	CLO 5	Evaluate the transfer function of signal flow graphs using Mason's gain formula and apply standard test signals for transient analysis.	PO 3	2
AEE009.06	CLO 6	Evaluate steady state errors and error constants for first and second order systems by using step, ramp and impulse signals.	PO 1, PO 9	1
AEE009.07	CLO 7	Apply Routh Hurwitz stability criterion to find the necessary and sufficient conditions for stability.	PO 3	3
AEE009.08	CLO 8	Analyze and apply the design procedures of root locus for stability and discuss the effect of poles and zeros on stability.	PO 3	2
AEE009.09	CLO 9	Implement controllers using proportional integral, proportional derivative and proportional integral derivative controllers.	PO 1, PO 12	2
AEE009.10	CLO 10	Understand the concept of frequency domain and discuss the importance of resonant frequency, resonant peak and bandwidth on stability.	PO 1, PO 9	2
AEE009.11	CLO 11	Evaluate the performance of stability using bode plot; polar plot and nyquist plot and calculate the gain crossover frequency and phase crossover frequency.	PO 3	1
AEE009.12	CLO 12	Analyze the gain margin and phase margin for higher order systems and demonstrate the correlation between time and frequency response.	PO 3	2
AEE009.13	CLO 13	Understand the concept of state, state variables and derive the state models from block diagrams.	PO 1	3
AEE009.14	CLO 14	Apply state space design techniques for modeling and control system design. Formulate and solve state-variable models of linear systems.	PO 1	2
AEE009.15	CLO 15	Apply analytical methods to system models: controllability, observability, and stability. Design a lag, lead and lag lead networks for stability improvement.	PO 1	1

CLO Code	CLO's	At the end of the course, the student will have the ability to	PO's Mapped	Strength of Mapping
AEE009.16	CLO 16	Applications of the principles of communication engineering and digital signal processing.	PO 9, PO 12	3

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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	3														
CLO 2	2												3		
CLO 3	3											1	2		
CLO 4			3												
CLO 5			2										1		
CLO 6	1								1						
CLO 7			3												
CLO 8			2										3		
CLO 9	3											2			
CLO 10	2								2				2		
CLO 11			1										1		
CLO 12			2										2		
CLO 13	3														
CLO 14	2												2		
CLO 15	1														
CLO 16									3			3	3		

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XI. ASSESSMENT METHODOLOGIES – DIRECT

CIE Exams	PO 1, PO 3, PO 9, PO 12	SEE Exams	PO 1, PO 3, PO 9, PO 12	Assignments	PO 1, PO 3	Seminars	PSO 1
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	**INTRODUCTION AND MODELLING OF PHYSICAL SYSTEMS**
Control systems: Introduction, open loop and closed loop systems, examples, comparison, mathematical models and differential equations of physical systems, concept of transfer function, translational and rotational mechanical systems, electrical systems, force voltage and force current analogy.	
Unit-II	**BLOCK DIAGRAM REDUCTION AND TIME RESPONSE ANALYSIS**
Block Diagrams: Block diagram representation of various systems, block diagram algebra, characteristics of feedback systems, servomotors, signal flow graph, Mason's gain formula; Time response analysis: Standard test signals, shifted unit step, ramp and impulse signals, shifting theorem, convolution integral, impulse response, unit step response of first and second order system, time response specifications, steady state errors and error constants.	
Unit-III	**STABILITY ANALYSIS AND CONTROLLERS**
Concept of stability: Necessary and sufficient conditions for stability, Routh's and Routh Hurwitz stability criterions. Root locus technique: Introduction, root locus concept, construction of root loci, graphical determination of k for specified damping ratio, relative stability, effect of adding zeros and poles on stability. Controllers: Proportional, derivative and proportional derivative, proportional integral and PID controllers.	
Unit-IV	**FREQUENCY DOMAIN ANALYSIS**
Frequency domain analysis: Introduction, frequency domain specifications, stability analysis from Bode plot, Polar plot, Nyquist plot, calculation of gain margin and phase margin, determination of transfer function, correlation between time and frequency response.	
Unit-V	**STATE SPACE ANALYSIS AND COMPENSATORS**
State Space Analysis**:** Concept of state, state variables and state model, derivation of state models from block diagrams, diagonalization, solving the time invariant state equations, state transition matrix and properties, concept of controllability and observability; Compensators: Lag, lead, lag lead networks.	
Text Books:	
1. J. Nagrath, M. Gopal, "Control Systems Engineering", New Age International Publications, 3rd Edition, 2007. 2. K. Ogata, "Modern Control Engineering", Prentice Hall, 4th Edition, 2003. 3. N. C. Jagan, "Control Systems", BS Publications, 1st Edition, 2007.	
Reference Books:	
1. A. Anand Kumar, "Control Systems", PHI Learning, 1st Edition, 2007. 2. S Palani, "Control Systems Engineering", Tata McGraw Hill Publications, 1st Edition, 2001. 3. N. K. Sinha, "Control Systems", New Age International Publishers, 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

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
1-5	Understand the different type of control systems.	CLO 1	T1:1.1
6-8	Analyze differential equations and mathematical model of control system.	CLO 2	T1:1.7
9-11	Identical transfer functions of mechanical and electrical systems.	CLO 3	T1:1.7
12-15	Understand the block diagram reduction techniques.	CLO 4	T1:2.1
16-18	Analyze the characteristics of feedback system and understand the concepts of servomotor.	CLO 4	T1:2.8
19-21	Apply Mason's gain formula to derive the transfer function using signal flow graph.	CLO 5	T1:3.7
22-24	Analyze time response for test signals in system.	CLO 6	T1:3.5
25-32	Apply time domain specifications to find steady state error and error constants.	CLO 6	T1:4.1
33-35	Understand the concepts of stability and apply Routh's Hurwitz criterions to find stability of the system.	CLO 7	T1:5.1
36-38	Apply root locus technique to examine the stability of the system.	CLO 8	T1:5.3
39-42	Analyze the effect of poles and zeros in transfer function and design controllers using PI, PD and PID controllers.	CLO 9	T1:5.3
43-44	Understand the concepts of stability in frequency domain.	CLO 10	T1:5.3
45-46	Apply the graphical method for determining the stability of a control system.	CLO 11	T1:6.1
47-49	Evaluate the transfer function using gain and phase margin.	CLO 12	T1:5.7
50-53	Understand the state variables and its models.	CLO 13	T1:6.1
54-57	Analyze different state models from block diagrams of the system. And controllability, observability of system model.	CLO 14	T1:7.1
58-60	Design a lag, lead and lag lead controllers and discuss the properties of state transition matrix.	CLO 15	T1:7.3

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

S No	Description	Proposed Actions	Relevance with POs	Relevance with PSOs
1	Control systems with real time examples.	Guest Lectures	PO 9	PSO 1
2	Time response analysis of feedback systems with transportation lag.	Seminars / NPTEL	PO 1	PSO 1
3	Design of digital controllers.	NPTEL	PO 3	PSO 1

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