Course Name: CONTROL SYSTEM-I
Course Code: EE 503
Credit: 4

Prerequisites:

To understand this course, the student must have idea of:

Sl. No.	Subject	Description	Level of Study
01	Mathematics	Linear Differential Equations, Laplace Transform	Class XII, 2nd Sem
02	Physics	Rotational Motion	Class XI
03	Circuit Theory	Network Theory	2nd Sem

Course Objective:

- To introduce different types of system and identify a set of algebraic equations to represent and model a complicated system into a more simplified form to interpret different physical and mechanical systems in terms of electrical system to construct equivalent electrical models for analysis.

- To employ time domain analysis to predict and diagnose transient performance parameters of the system for standard input functions and identify the needs of different types of controllers and compensator to ascertain the required dynamic response from the system

- Formulate different types of analysis in frequency domain to explain the nature of stability of the system.

Course Outcomes:
At the end of the course, a student will be able to:

1. **Categorize** different types of system and **identify** a set of algebraic equations to represent and model a complicated system into a more simplified form.

2. **Characterize** any system in Laplace domain to illustrate different specification of the system using transfer function concept.
3. **Interpret** different physical and mechanical systems in terms of electrical system to construct equivalent electrical models for analysis.

4. **Employ** time domain analysis to **predict** and **diagnose** transient performance parameters of the system for standard input functions.

5. **Formulate** different types of analysis in frequency domain to explain the nature of stability of the system.

6. **Identify** the needs of different types of controllers and compensator to ascertain the required dynamic response from the system.

CO- PO mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1	3	1	-	2	2	2	-	-	1	1	1	2
2	3	2	-	2	2	1	-	-	1	-	1	2
3	2	3	2	2	1	2	1	1	1	1	1	2
4	2	2	1	2	2	1	1	-	-	1	-	1
5	3	3	2	2	2	1	1	-	1	-	1	2
6	2	3	2	2	1	1	1	1	-	1	1	1

Syllabus Indicating CO:

Module No.	Content	Relevant CO's
1	**Introduction to control system:** Concept of feedback and Automatic control, Effects of feedback, Objectives of control system, Definition of linear and nonlinear systems, Elementary concepts of sensitivity and robustness. Types of control systems, Servomechanisms and regulators, examples of feedback control systems. Transfer function concept. Pole and Zeroes of a transfer function. Properties of Transfer function. **Mathematical modeling of dynamic systems:** Translational systems, Rotational systems, Mechanical coupling, Liquid level systems, Electrical analogy of Spring–Mass-Dashpot system. Block diagram representation of control systems. Block diagram algebra. Signal flow graph. Mason's gain formula. **Control system components:** Potentiometer, Synchros, Resolvers, Position encoders. DC and AC tacho-generators. Actuators. Block diagram level description of feedback control systems for position control, speed control of DC motors, temperature control, liquid level control, voltage control of an Alternator.	**CO1,CO2,CO3**
2	**Time domain analysis:** Time domain analysis of a standard second order closed loop system. Concept of undamped natural frequency, damping, overshoot, rise time and settling time. Dependence of time domain performance parameters on natural frequency and damping ratio. Step and Impulse response of first and second order systems. Effects of Pole and Zeros on transient response. Stability by pole location. Routh-Hurwitz criteria and applications. **Error Analysis:** Steady state errors in control systems due to step, ramp and parabolic inputs. Concepts of system types and error constants.	**CO1,CO4**

3	**Stability Analysis:** Root locus techniques, construction of Root Loci for simple systems. Effects of gain on the movement of Pole and Zeros. **Frequency domain analysis of linear system:** Bode plots, Polar plots, Nichols chart, Concept of resonance frequency of peak magnification. Nyquist criteria, measure of relative stability, phase and gain margin. Determination of margins in Bode plot. Nichols chart. M-circle and M-Contours in Nichols chart.	**CO2,CO5**
4	**Control System performance measure:** Improvement of system performance through compensation. Lead, Lag and Lead- lag compensation, PI, PD and PID control.	**CO1,CO6**

Gaps in Syllabus:

Sl. No.	Gap	Action taken	Relevance to POs
1	**Introduction to Control system***: A controller is a* ***control system*** *that manages the behavior of another device or* ***system****. Compensator. A Compensator is a* ***control system*** *that regulates another* ***system****, usually by conditioning the input or the output to that* ***system*** **Topics covered:** Brief History of Automatic Control.	Additional lecture classes were organized providing notes, and by solving numerical problems.	**PO 2, PO 7**
2	**Frequency Response Analysis:** *The* ***frequency response*** *is a representation of the* ***system's response*** *to sinusoidal inputs at varying frequencies. The output of a linear* ***system*** *to a sinusoidal input is a sinusoid of the same* ***frequency*** *but with a different magnitude and phase* **Topics covered:** Frequency Domain specifications from the plots – Constant M and N Circles – Nichol's Chart – Use of Nichol's Chart in Control	Additional **lecture classes** are organized to cover the topics.	**PO 2, PO 5**
3	**Feedback Control System Characteristics:** *A* ***control system*** *is formed by interconnecting various components to give a desired* ***system*** *response. An open-loop or non-****feedback system****, with the help of a controller or actuating device, directly generates the output in response to an input.* **Topics covered:** The Cost of Feedback	These are emergent topics under application of drives, hence additional classes were taken and notes were provided.	**PO 4, PO 5**
4	**The Performance of Feedback Control Systems:** *A* ***feedback*** *loop is a common and powerful tool when designing a* ***control system****.* ***Feedback*** *loops take the* ***system*** *output into consideration, which enables the* ***system*** *to adjust its performance to meet a desired output response.* **Topics covered:** Effects of a Third Pole and a Zero on the Second-Order System Response	Extra class was arranged in a workshop and notes provided and assignment given.	**PO1, PO 2**
5	**Root Locus Method**: In control theory and stability theory, **root locus** analysis is a graphical **method** for examining how the **roots** of a system change with variation of a certain system parameter, commonly a gain within a feedback system. **Topics covered:** Sensitivity and the Root Locus	Assignment was given	**PO 3, PO8**

6	**Design of Feedback Control Systems:**A feedback loop is a common and powerful tool when designing a control system. Feedback loops take thesystem output into consideration, which enables thesystem to adjust its performance to meet a desired output response. **Topics Covered:** Approaches to System Design, Cascade Compensation Networks, Phase-Lead Design Using the Bode Diagram	Additional **lecture classes** are organized to cover the topics.	**PO 3, PO 8** **PO 7**

Lecture Plan:

Cl. No.	Date	Topics	Remarks
1		Concept of feedback and Automatic control, Effects of feedback,Objectives of control system,	
2		Examples of feedback control systems, transfer function concept. Pole and Zeroes of a transfer function. Properties of Transfer function	Problems to be solved
3		Definition of linear and nonlinear systems, Elementary concepts of sensitivity and robustness. Types of control systems	
4& 5		Block diagramrepresentation of control systems. Block diagram algebra.	Problems to be solved
6		Signal flow graph. Mason's gain formula	Problems to be solved
7& 8		Translational systems, Rotational systems, Mechanicalcoupling, Electrical analogy of Spring–Mass-Dashpot system.	Problems to be solved
9		Time domain analysis of a standard second order closed loop system	Problems to be solved
10		Concept of undamped natural frequency, damping, overshoot, rise time and settling time.	Problems to be solved
11		Dependence of timedomain performance parameters on natural frequency and damping ratio.	
12, 13& 14		Step and Impulse response of first and second order systems.	Problems to be solved
15		Effects of Pole and Zeros on transient response. Stability by pole location.	

16 & 17		Routh-Hurwitz criteria and applications.	Problems to be solved
18		Steady state errors in control systems due to step, ramp and parabolic inputs.	Problems to be solved
19		Concepts of system types and error constants.	Problems to be solved
20		Root locus techniques	
21,22& 23		Construction of Root Loci for simple systems	Problems to be solved
21		Effects ofgain on the movement of Pole and Zeros	
22, 23		Bode plots	Problems to be solved
24 & 25		Determination of margins in Bode plot	Problems to be solved
26& 27		Polar plots	Problems to be solved
28		Nyquist criteria,	
29& 30		Measure of relative stability, phase andgain margin.	Problems to be solved
31		Nichols chart, Concept ofresonance frequency of peak magnification.	Qualitative Discussion
32 & 33		M-circle and M-Contours inNichols chart.	Qualitative Discussion
34		Improvement of system performance through compensation.	
35 & 36		Lead, Lag and Lead- lag compensation,	
37 &38		PI, PD control	
39		PID control	
40		Servomechanisms and regulators, examples of feedback control systems.	Qualitative Discussion
41		Potentiometer, Synchros, Resolvers, Position encoders. DC and ACtacho-generators. Actuators.	Qualitative Discussion

		Block diagram level description of feedback control systems for positioncontrol, speed control of DC motors, temperature control, liquid level control, voltage control of anAlternator.	

Recommended Books:

1. Automatic Control Systems (With Matlab Programs), *HASAN SAEED*, S. K. Kataria& Sons
2. Control systems, K.R. Varmah, McGraw hill
3. Control System Engineering, D. Roy Chowdhuri, PHI
4. Digital Control system, B.C. Kuo, Oxford University Press.
5. Control System Engineering, I. J. Nagrath& M. Gopal. New AgeInternational Publication
6. Modern Control Engineering, K. Ogata, 4th Edition, Pearson Education

Subject Teacher:

Signature: