

**COURSE TITLE** : CONTROL SYSTEMS  
**COURSE CODE** : 5043  
**COURSE CATEGORY** : E  
**PERIODS/WEEK** : 4  
**PERIODS/SEMESTER** : 52/5  
**CREDITS** : 4

**TIME SCHEDULE**

MODULE	TOPICS	PERIODS
1	Introduction To Control System.	13
2	Systems and Transfer Functions.	13
3	Time Response Analysis.	13
4	Stability Analysis.	13
<b>TOTAL</b>		<b>52</b>

Course General Outcome:

Module	GO	On completion of the study of this course the students will be able:
1	1	To understand the basics of control system.
	2	To understand Laplace and inverse Laplace transform.
2	3	To know systems and transfer function.
	4	To understand methods of obtaining transfer function
3	5	To understand time response analysis.
	6	To understand stability of a system and Routh stability criterion.
4	7	To understand bode plot and root locus techniques for stability analysis.

GO - General Outcome

On the completion of the study the student will be able:

**MODULE I INTRODUCTION TO CONTROL SYSTEM**

**1.1.0 To understand the basics of control system.**

- 1.1.1 To understand physical model of control system.
- 1.2.1 To analyze mathematical model of control system.
- 1.1.2 To explain linear time invariant and linear time variant system.
- 1.1.3 To know open loop and closed loop control systems.

### **1.2.0 To understand Laplace and inverse Laplace transforms.**

- 1.2.1 To discuss Laplace transforms.
- 1.2.2 To find the Laplace transform of  $e^{at}$ ,  $e^{-at}$ ,  $t$ ,  $\sin at$  and  $\cos at$ .
- 1.2.2 To find the Laplace transform of test inputs such as step, ramp, parabolic, impuls inputs.
- 1.2.3 To state Laplace transform theorems - differentiation theorem and integration theorem.
- 1.2.4 To find Inverse Laplace transforms using partial fraction method to solve simple problems.

## **MODULE II SYSTEMS AND TRANSFER FUNCTIONS**

### **2.1.0 To know systems and transfer function.**

- 2.1.1 To define transfer function.
- 2.1.2 To find the order of transfer function.
- 2.1.3 To write transfer function of linear system.
- 2.1.4 To derive of general transfer function of Mechanical Translational system and rotational system.
- 2.1.5 To derive the transfer function of Electrical circuits – R, L and C (series & parallel).
- 2.1.6 To describe force/torque - voltage and force/torque - current analogy.

### **2.2.0 To understand methods of obtaining transfer function.**

- 2.2.1 To explain Block diagram reduction rules.
- 2.2.2 To find the overall transfer function of control systems by block diagram.
- 2.2.3 Reduction rules (single input- single reduced output systems).
- 2.2.4 To define the parameters of signal flow graph.
- 2.2.5 To write Mason's gain formula.
- 2.2.6 To draw SFG from block diagram.
- 2.2.7 To obtain overall transmittance of control system by signal flow graph.

## **MODULE III TIME RESPONSE ANALYSIS**

### **3.1.0 To understand time response analysis.**

- 3.1.1 To explain the time response of first order system.
- 3.1.2 To find the response of first order systems such as step, ramp, and impulse inputs.
- 3.1.3 To define the type of a system.
- 3.1.4 To define static error coefficients such as static position, velocity & acceleration error coefficient.
- 3.1.5 To derive steady state error in terms of  $K_p$ ,  $K_v$  &  $K_a$  for Type 0, Type 1, Type 2 Systems.

### **3.2.0 To understand Routh Hurwitz criterion.**

- 3.2.1 To state absolute stability, relative stability and marginal stability.
- 3.2.2 To explain Routh Hurwitz criterion.
- 3.2.3 To solve simple problems using Routh Hurwitz criterion.

## **MODULE IV STABILITY ANALYSIS**

### **4.1.0 To understand bode plot and root locus techniques of stability analysis.**

- 4.1.1 To draw Bode plot for simple transfer functions.  $K$ ,  $Ks$ ,  $K/s$ ,  $1+Ts$ ,  $Ts$ ,  $1/1+Ts$ ,  $1/1Ts$ .
- 4.1.2 To explain gain cross over frequency, phase cross over frequency, gain margin and phase margin.
- 4.1.3 To describe the Procedure to construct Root locus.
- 4.1.4 To construct Root Locus for transfer functions (Single poles only).

## **CONTENT**

### **MODULE I Introduction to control system**

Basics of control system - physical model - mathematical model of control system - linear time invariant and linear time variant system - open loop and closed loop control systems - Laplace transforms - Laplace transform of  $e^{at}$ ,  $e^{-at}$ ,  $t$ ,  $\sin at$  and  $\cos at$  - Laplace transform of step, ramp, parabolic, impulse inputs - Laplace transform theorems - differentiation theorem and integration theorem - Inverse Laplace transforms - partial fraction method to solve simple problems.

### **MODULE II Systems and Transfer Functions**

Transfer function - definition and order - transfer function of linear system - general transfer function of Mechanical Translational system and rotational system - transfer function of Electrical circuits –  $R$ ,  $L$  and  $C$  (series & parallel) - force/torque - voltage and force/torque - current analogy - block diagram reduction – rules - overall transfer function of control systems using block diagram reduction rules - signal flow graph - parameters - Mason's gain formula - procedure to draw SFG from block diagram - overall transmittance of control system by signal flow graph.

### **MODULE III Time Response analysis**

Time response analysis - time response of first order system - response of first order system for step, ramp, and impulse inputs - type of a system - static error coefficients - static position, velocity & acceleration error coefficient - steady state error in terms of  $K_p$ ,  $K_v$  &  $K_a$  for Type 0, Type 1, Type 2

Systems - Routh Hurwitz criterion - absolute stability, relative stability and marginal stability – simple problems using Routh Hurwitz criterion

#### **MODULE IV Stability analysis**

Bode plot – stability analysis of simple transfer functions.  $K$ ,  $Ks$ ,  $K/s$ ,  $1+Ts$ ,  $1-Ts$ ,  $1/(1+Ts)$ ,  $1/(1-Ts)$  - gain cross over frequency, phase cross over frequency, gain margin, phase margin - Root locus - Procedure to construct - Root Locus for single pole transfer functions.

#### **TEXT BOOK**

1. Control systems Engg -I.J.Nagarath, N. Gopal (New Age International Publisher).
2. Control Systems- R.S. Manke ( Khanna Publisher).

#### **REFERENCE**

1. Modern Control Engineering - Katsuhiko Ogata – PHI.
2. Control Systems Engineering - R.Anandanatarajan.P.Ramesh Babu (Scitech Publisher).