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| **Subject: Control Systems****(Code: MET353)** | **Year & Semester: B. Tech** **Mechanical Engineering** **3rd Year & 6th Semester** | **Total Course Credit: 4** |
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| 3 | 1 | 0 |
| **Evaluation Policy** | Mid-Term | Class Assessment | End-Term |
| 30 Marks | 10 Marks | 60 Marks |

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

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| **CO1:** Develop the mathematical models of LTI dynamic systems, determine their transfer functions, describe quantitatively the transient response of LTI systems, interpret and apply block diagram representations of control systems and understand the consequences of feedback. |
| **CO2:** Use poles and zeroes of the transfer functions to determine the time response and performance characteristics and design PID controllers using empirical tuning rules. |
| **CO3:** Determine the stability of linear control systems using the Routh-Hurwitz criterion and classify systems as asymptotically and BIBO stable or unstable. |
| **CO4:** Determine the effect of loop gain variations on the location of closed-loop scales, sketch the root locus and use it to evaluate parameter values to meet the transient response specification of closed loop systems. |
| **CO5:** Define the frequency response and plot asymptotic approximations to the frequency response function of a system. Sketch a Nyquist diagram and use the Nyquist criterion to determine the stability of a system. |

**Detailed Syllabus:**

**UNIT I**

Introduction to Control Systems, Examples of Control Systems, Closed-Loop Control Versus Open-Loop Control, Laplace Transforms, Transfer Functions and Block Diagrams, Mathematical Modeling of Control Systems, Differential Equation or Time-Domain Models of Linear Time-Invariant (LTI), Transfer Function or s-Domain Models, Poles and Zeros of the Transfer function, Convolution Integral and Impulse-Response Function, Mathematical Modeling of Mechanical Systems and Electrical Systems

**UNIT II**

Transient and Steady-State Response Analyses, Transient Response Analysis of First-Order Systems, Second-Order Systems and Higher-Order, Systems, Performance characteristics of control systems, Transient Response Specifications, Rise Time, Peak Time, Maximum, Overshoot, Settling Time, Steady-State Errors in Unity-Feedback, Control Systems, Basic Control Actions, Effects of Proportional, Derivative and Integral Control actions on system performance, PD, PI, and PID Controllers

**UNIT III**

Stability of Linear Time-Invariant (LTI) Systems, Asymptotic Stability, Bounded Input Bounded Output (BIBO) Stability, Routh’s Stability Criterion, Control Systems Analysis and Design by the Root-Locus Method, Some Developmental Concepts, Rules of Construction, Plotting Root Loci with MATLAB, Root-Locus Approach to Control-Systems Design

**UNIT IV**

Control Systems Analysis and Design by the Frequency-Response Method, Obtaining Steady-State Outputs to Sinusoidal Inputs, Bode Diagrams, Log-Magnitude-versus-Phase Plots, Integral and Derivative Factors, first-Order Factors, Quadratic Factors, Polar Plots, Nyquist Stability Criterion, Experimental Determination of Transfer Functions, Control Systems Design by Frequency-Response Approach

**Text Book:**

K. Ogata, Modern Control Systems, Prentice-Hall of India, 5th edition, 2010 (ISBN 10: 0-13-615673-8)

**Reference Books:**

Norman S. Nise, Control Systems Engineering, Fourth Edition, 2004, John Wiley and Sons