# TKU212243

Control Systems Engineering

Teknik Kendali

## BASIC INFORMATION

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| **Course Credit** | 3 / 150 minutes per Week |
| **Course Type** | Required |
| **Course Classification** | Engineering Topics |
| **Prerequisites** | Signal and Systems; Differential Equations; Complex Variable Analysis |

## STUDENT AND LEARNING OUTCOMES

**Covered Student Outcomes**

Development of Engineering Solution (KP.2)

Engineering Design (KP.3)

**Learning Outcomes**

**LO1** Students are able to understand the concept of control systems: negative feedback, time response and stability.

**LO2** Students are able to analyze control systems using root locus and frequency domain methods.

**LO3** Students are able to model dynamics systems into transfer function and state space representations.

**LO4** Students are able to design Lead, Lag, Lead-Lag, and PID Control Family to stabilize a plant or to improve its time response using frequency domain methods.

## COURSE DESCRIPTION

This course gives an initial treatment for control engineering necessary for all Electrical Engineering Students. Emphasis is given to classical control analysis using frequency domain approaches.

## TOPICS

**1. Introduction to Control Systems**

1.1 Examples of Control Systems

1.2 Closed-Loop Control versus Open-Loop Control

**2. Mathematical Modeling of Control Systems**

2.1 Transfer Function and impulse Response Function

2.2 Modeling in state space

2.3 State-Space Representation of Scalar Differential Equation System

2.4 Transformation of Mathematical models with MATLAB

2.5 Linearization of Nonlinear Mathematical Models

**3. Mathematical Modeling of Dynamical Systems**

3.1 Mathematical Modeling of Mechanical Systems

3.2 Mathematical Modeling of Electrical Systems

3.3 Liquid-Level Systems

3.4 Pneumatic Systems

3.5 Hydraulic Systems

3.6 Thermal Systems

**4. Transient and Steady-State Response Analyses**

4.1 First-Order Systems

4.2 Second-Order Systems

4.3 Higher Order Systems

4.4 Routh’s Stability Criterion

4.5 Effects of Integral and Derivative Control Actions on System

4.6 Steady-State Errors in Unity-Feedback Control Systems

**5. Control Systems Analysis and design by the Root-Locus Method**

5.1 Root-Locus Plots

5.2 Root-Locus Approach to control Systems Design

5.3 Lead Compensation

5.4 Lag Compensation

5.5 Lag-Lead Compensation

**6. Control Systems Analysis and Design by the Frequency Response Method**

6.1 Bode Digrams

6.2 Polar Plots

6.3 Log-Magnitude-versus-Phase plots

6.4 Nyquist Stability Criterion

6.5 Stability Analysis

6.6 Relative Stability Analysis

6.7 Closed-Loop Frequency Response of Unity-feedback Systems

6.8 Experimental Determination of Transfer functions

6.9 Control Systems design by Frequency Response Approach

6.10 Lead Compensation

6.11 Lag Compensation

6.12 Lag-Lead Compensation

**7. PID Controllers and Modified PID Controllers**

7.1 Ziegler- Nichols Rules for tuning PID controllers

7.2 Design of PID Controllers with Frequency Response Approach

7.3 Design of PID Controllers with Computational Optimization Approach

7.4 Modification of PID Control Schemes

7.5 Two-Degrees-of-freedom PID Control Schemes

7.6 Zero Placement Approach to Improve Response

## REFERENCES

[1] Ogata, Katsuhiko, and Yanjuan Yang. Modern control engineering. Vol. 4. India: Prentice hall, 2002.

[2] Nise, Norman S. Control systems engineering. John Wiley & Sons, 2020.

[3] Dorf, Richard C., and Robert H. Bishop. Modern control systems. Pearson, 2011.