**AE 3531 - Control System Analysis and Design**

**Hours:** 3-0-3

**Catalog Description:** Control system performance analysis and specifications, classical methods of control system analysis and design, introduction to modern control methods.

**PREREQUISITS:**

AE3530

**TEXTBOOKS/REFERENCE:**

1. Ogata, K., *Modern Control Engineering,* Prentice Hall, 2002.
2. Kuo, B.C., *Automatic Control Systems*, Prentice Hall, 1991.
3. Franklin, G.F., Powell, J.D., and Emami-Naeini, A., *Feedback Control of Dynamic Systems*, Addison Wesley, 1994.
4. Dorf, R.C., and Bishop, R.H., *Modern Control Systems*, Prentice Hall, 2001.
5. Nise, N.S., *Control Systems Engineering*, Benjamin-Cummings, 1995.

**COURSE OBJECTIVE:** Provide students with a foundational understanding of classical methods of feedback control system analysis and design and an introduction to modern control methods.

**LEARNING OUTCOMES:**

Students will a mastery level of:

1. Analysis of Controlled Linear SISO Systems
2. Design of Controlled Linear SISO Systems

Students will gain exposure level to:

1. Analysis of Controlled Linear MIMO Systems
2. Design of Controlled Linear MIMO Systems
3. Relevant Applications to Aerospace Systems

**TOPICAL OUTLINE: Hrs**

1. Introduction to Control Systems 5

Examples of Control Systems

Open-Loop versus Closed-Loop Control

Feedback Block Diagrams and their Simplification

Mason’s Gain Formula

Mathematical Modeling of Dynamical Systems

Modeling in the State Space

Transfer Functions and Impulse Response Functions

1. Transient and Steady-State Response Analysis 6

First- and Second-Order Systems

Higher-Order Systems

Transient Response Analysis

Time Domain Performance Specifications

Delay Time, Rise Time, Peak Time, Maximum Overshoot,

and Settling Time

Stability Analysis and Routh’s Stability Criterion

Proportional, Derivative, and Integral Control Actions

Steady-State Error Analysis in Feedback Systems

1. Root Locus Analysis 5

Root Locus Plots

General Rules for Constructing the Root Locus

Positive feedback Systems

Parameter Variation

1. Frequency-Response Analysis 7

Bode Diagrams

Nyquist Plots

Stability and Relative Stability Analysis

Systems with Transport Lags

Gain and Phase Margins

Closed-Loop Frequency Response

Frequency Domain Performance Specifications

Peak Resonance, Resonant Frequency, and Bandwidth

1. Time and Frequency Domain Design of Control Systems 6

PID Design

Lead-Lag Compensation

Sensitivity and Complimentary Sensitivity Transfer Functions

Disturbance Rejection and Loop Shaping

1. Analysis and Control Design in the State Space 9

Lyapunov Stability, Asymptotic Stability, Input-Output Stability

State Transition Matrix

Controllability and Observability

The Lyapunov Equation

Full-State Feedback Control Design and Pole Placement

Optimal State Space Control System Design

Linear Quadratic Regulator

1. Aerospace Applications 4

Classical Control Theory

Modern Control Theory

Mid Term Exam and Quizzes 3

Total 45