**ELEN 4310 ‑- Control Systems**

**Credits and contact hours:** 3 credit course, meeting the equivalent of three 50 minute class periods per week.

**Course Coordinator**: Ronald H. Brown

**Course Material:**

Richard Dorf and Robert Bishop, Modern Control Systems, 12th ed., Prentice Hall, 2011

Class notes (on D2L) and readings from various sources; see reference list.

MATLAB: Available at http://www.marquette.edu/its/help/matlab/ (no cost to Marquette Students)

**Course Description:**

Review of continuous-time linear systems. Time-domain system analysis. Time-domain design of lead/lag and PID controllers. Root-locus technique. Frequency-domain system analysis including Nyquist, Bode, and Nichols analysis and relative stability. Frequency-domain design of lead/lag and PID controllers.

**Prerequisites:** ELEN 3020 Linear Systems with a minimum grade of C.

**Selected Elective** in the Signals, Systems, and Control area, COEN Hardware area (depth only)

**Contribution to Professional Component**: Engineering Science 50%

Engineering Design 50%

**Course Goals:**

This course is designed to give senior and graduate students the ability to analyze and design control systems, to analyze, design, and simulate control systems using computers, and to implement control algorithms in analog circuitry.

**Course Objectives:**

*By the end of this course you should be able to:*

* Represent linear systems with transfer functions, block diagrams, and signal flow graphs; and to transform a system from one representation to another.
* Model linear translational and rotational mechanical systems.
* Model Operational Amplifier circuits.
* Determine the stability of transfer functions.
* Determine the response of linear systems to inputs, including steady state error.
* Recognize step response characteristics of second order systems, and approximate step responses of higher order systems.
* Apply the root locus technique
* Analyze frequency domain characteristics of systems, including phase and gain margins from Bode plots.
* Design controllers using P, PI, PD, PID, Phase-Lead, Phase-Lag, Lead-Lag controllers, including the characteristics and impacts of each controller.

**Contribution to Program Objectives:** partial fulfillment of criterion 3 objectives A, C, E, G, and K.

**Brief list of topics to be covered**

Chapter 1. **Introduction to Control Systems 1 week**

Chapter 2. **Mathematical Models of Systems 3 weeks**

 Mathematical Foundation

 Linearity

 Laplace transforms, properties

 Solution to ODEs using Laplace

 Solution to ODEs using numerical methods

 Transfer functions

 Block diagrams/signal flow graphs

 Mason's gain formula

 Review Stability (6.1, 6.2)

Modeling

 Linear mechanical systems

 Rotational mechanical systems

 DC motors

 Electric circuits

Chapter 3. **State Variable Models** (brief) **1 week**

Chapter 4. **Feedback Control System Characteristics 2 weeks**

Chapter 5. **The Performance of Feedback Control Systems**

 Steady state response

 Transient response

 Second order systems

Chapter 7. **Root Locus Method 1 week**

Chapter 8. **Frequency Response Methods 2 weeks**

Chapter 9. **Stability in the Frequency Domain**

Relative Stability (6.3)

 Bode plots, phase and gain margins

Chapter 10. **Design of Feedback Control Systems 4 weeks**

 Phase Lead/Phase Lag compensation

 Lead-lag compensation

 PI, PD, and PID controllers