**ELEN 4320 ‑- Digital Control Systems**

**Class schedule:** 3 credit course, meeting the equivalent of three 50 minute class periods per week.

**Course Coordinator**: Edwin Yaz

**Course Materials:**

Optional: Benjamin C. Kuo, Digital Control Systems, 2nd. Ed., Oxford Press, 1992.

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 sampling process, discrete time linear systems analysis, and Z-transforms. Discrete time and sampled data state variable analysis. Stability analysis, time-domain, and frequency-domain analysis and design. Digital Control Design. Implementation issues.

**Prerequisites:** ELEN 3020 Linear Systems Analysis.

**Selected Elective** in the Signals, Systems, and Control area.

**Contribution to Professional Component**:

Engineering Science 50%

Engineering Design 50%

**Course Goals:**

This course is designed to give Electrical and Computer Engineering students the basic tools to understand, analyze, design digital control algorithms.

**Course Objectives:**

By the end of this course, the student should be able to:

* Explain the concepts required to design and implement a digital control system.
* Use the mathematical models of digital control systems components.
* Analyze digital control systems to determine Transfer Function and State Space representations.
* Use the Z-Transform to analyze Transfer Function representations in order to determine system responses to given input signals, frequency domain characteristics, and stability.
* Generate and use the State Space representations to analyze and design digital controllers.
* Design phase lag, phase lead, phase lead-lag, PI, PD, and PID digital controllers.

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

**Brief list of topics to be covered:**

 Introduction/Review 1 week

 Review of continuous-time systems, Laplace transforms, Transfer functions, general gain formula.

 Review of discrete-time signals.

 Signal Conversion and reconstruction. 2 weeks

 Sampling, Laplace transforms of sampled signals, Sampling Theorem.

 Data Reconstruction, Zero order hold, frequency domain analysis.

 Z-Transform. 1 week

 Definition of the Z-transform from both time and Laplace domains.

 Properties and Theorems of Z-transforms.

 Inverse Z-transforms.

 Discrete-time systems analysis. 1 week

Solutions of difference equations via recursion and Z-transforms.

 Decomposition of transfer functions and difference equations.

 Difference equations of continuous time systems.

 Introduction to the PID controller

 Computer simulations to solve difference equations.

 Implementation of Digital Control. 1 Week . 1 Week 1 1 2 weeks

 Finite word length effects.

 quantization

 truncation of multiplication

 coefficient quantization and effect on placement of poles.

 Discrete-time State Variables. 1 week

 Defining state variables.

 Similarity transforms, eigenvalues, eigenvectors

 Solutions of state equations, the state transition matrix

 Time-Domain Analysis. 3 weeks

 Step responses of first and second order systems.

 Mapping of s-plane to z-plane/effect of pole locations on natural frequency, damping ratio, overshoot, etc.

 Frequency Domain Analysis and Design. 3 weeks

 Review of Bode plots

 Relative stability, gain and phase margins

 Controller design

 Phase lead, phase lag, phase lead-lag compensators

 P, PD, PI, and PID controllers