ECE 4121: Digital Control Systems
Credits and contact hours: 3 Credits (Two 75-minute lectures per week)
Instructor: Krishna R. Pattipati
Textbooks:

Pattipati, K.R., and David L. Kleinman, Notes for a Comprehensive Course on Digital Control Systems, 2018.
Phillips, C.L., H. Troy Nagle and A. Chakrabortty, Digital Control System Analysis & Design, Pearson, 2015 (ISBN-10: 0-13-293831-6; ISBN-13: 978-0-13-293831-6.
Franklin, G. F., J.D. Powell, and M.L. Workman, Digital Control of Dynamic Systems, Ellis-Kagle Press, 2006 (ISBN-10: 0-9791226-0-0; ISBN-13: 978-0-9791226-0-6)
Other supplemental materials: Selected reference materials/articles posted online

***Specific course information*:**

a. ***Catalog Description***: Analysis and design of control systems incorporating digital computer as the controlling element. Building blocks of digital control. Measures of control system performance. Frequency domain and state variable methods of control design. Optimal control methods. State variable estimation. Issues of Implementation. Use of computer-aided software tools for simulation and design.
b. *Prerequisite*: ECE 3111: Systems Analysis
c. *Required, elective, or selected elective:* Selected elective (CMPE)

***Specific goals for the course*:**

a. *Specific outcomes of instruction*: Students will be able to specify and design digital control systems using design techniques, which span both frequency domain and state variable methods, supported by computational analysis.
b. *ABET Criterion 3 Student Outcomes addressed by the course*:

(1) an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
Students learn to mathematically model engineering systems and apply frequency domain and state variable techniques to analyze and design computer-controlled engineering systems. The application of the theory to contemporary problems (e.g., cyber-physical system, robots, smart buildings, smart grid, intelligent highways, biological control systems, spacecraft, automobiles, aircraft, ships, etc.) is emphasized through homework problems and design projects.

(2) an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
Students learn to specify control system requirements, design and simulate systems, interpret the effects of sampling, system performance sensitivity to changes in model and controller parameters, and effects of noise. The wide applicability of systems engineering techniques in cyber-physical systems, medicine, transportation, smart buildings, smart grid, economics, business and other societal systems is emphasized.

(3) an ability to communicate effectively with a range of audiences

Students write project reports in the form of a journal paper and provide power point slides (45-60 slides). Each team is expected to make two presentations on their project results during the course.

(4) an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider

the impact of engineering solutions in global, economic, environmental, and societal contexts
n/a

(5) **an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives**
Students work in teams on a design project to model a physical system, including the sensors and actuators, and design digital controllers to meet desired performance characteristics and cost constraints of a system. MATLAB/ Simulink implementation and extensive testing are a must.

(6) **an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions**
Students conduct simulation studies on the design by (1) varying sampling rates, (2) including actuator nonlinearities, (3) including the effects of sensor noise and disturbances, (4) incorporating uncertainties associated with model parameters.

(7) **an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.**
Students use the web, library databases, and other resources for their technical reports. The course emphasizes that advanced techniques and applications of the theory must be mastered throughout one's professional career to become successful.

Topics covered:

- Mathematical Modeling of Systems and Linearization.
- Feedback Control Structures for Continuous-time Systems, Classification of Control Design Techniques, Digital Control Loop Structures, Discrete-time System Stability, Continuous-time-vs.-Discrete-time Relationships
- Digital Interfacing, Signal Sampling and Data Reconstruction, Discretization of Continuous-time Systems
- Design Process, Performance Criteria, Implementation Issues: Alternate structures, effects of computer accuracy, Propagation of round-off errors, Control Systems design Evaluation and Simulation
- Analog and Digital Sensors & Continuous and Incremental Actuators
- Classical SISO (continuous-time) Control Design Methods (Lag, Lead, Lead-Lag, PID and IMC Design)
- Compensator Design via Discrete-equivalent and Direct Methods (Root locus and w-plane Design Methods)
- State variable Feedback (SVFB) via Discrete-equivalent and Pole Placement
- Linear Quadratic Regulator (LQR) Control
- H_2 and H_∞ optimal control (if time permits)
- Numerical Optimization and Non-linear Control (if time permits)