Catalog Description: EEC 440 Control Systems (3-0-3).
Pre-requisites: EEC 315 or EEC 316
Analysis and design of control systems. Topics covered include: the use of feedback; modeling and the use of mathematical model in understanding behavior of dynamic systems; useful design tools such as PID, root-locus, loop shaping, pole placement; robustness in stability and performance; real world problem solving using control theory.


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Course Objectives: This course is designed to give students ability to
1. Understand the basic concepts of feedback and see how they are used for control purposes;
2. Derive mathematical model based on first principle or time response and relate its parameters to the behavior of dynamic systems;
3. Solve control problems by using appropriate design tools;
4. Understand design constraints, such as inaccuracies of the model and saturation of the actuator, and produce robust control solutions.

Prerequisites by Topic:
1. Linear differential equations;
2. Linear algebra;
3. Laplace Transform analysis of linear systems;
4. Transfer function, poles and zeros;
5. Frequency response of linear systems
6. Bode diagrams

Fulfillment of EE and CE Program Objectives and Outcomes:

Objectives:
1. Practice electrical engineering
2. Define and diagnose problems, and provide and implement electrical engineering solutions in an industrial environment

Outcomes:
a. An ability to apply knowledge of mathematics, science, and engineering to electrical engineering
c. An ability to design a system, component, or process to meet desired needs
e. An ability to identify, formulate, and solve electrical engineering problems
k. An ability to use the techniques, skills, and modern engineering tools necessary for electrical engineering practice.

**Topics:**

1. Introduction 2
2. Closing the loop: the empirical PID design 2
3. Introduction to Matlab and Simulink 2
4. A motion control theme problem 2
5. Review of Laplace and Fourier Transforms 2
6. Modeling: Transfer function
   the time response based method 2
   the first principle based method 4
7. Open Loop time response: how poles and zeros affect system behavior 4
8. Closed-loop response: determine steady state error using the final value theorem 2
9. Frequency response analysis of control systems
   a) Nyquist stability theorem and stability margins 4
   b) Robust stability in the presence of unmodeled dynamics 4
10. Control Design Methods
    a) Design criteria: transient response, steady state error, disturbance rejection, noise sensitivity, stability margin, unmodeled dynamics 2
    b) PID revisit: the root-locus method 4
    c) Loop shaping method: 4
    d) Design examples 2
11. Exam 2
12. Holidays 2
Total 46

**Design Projects:** Students are required to complete at least three design projects:
   a) Empirical PID design;
   b) Pole placement design (root-locus);
   c) Loop shaping design.

**Non-Design Projects:** Students generally complete one non-design project regarding the open and closed-loop time response.

**Computer Usage:** All projects require extensive use of Matlab/Simulink. Students will achieve proficiency in using the software to model, design and simulate a complete control system.

**Estimated ABET Category Content:**

Engineering Topics: 3 credits, or 100%

Prepared by Dr. Zhiqiang Gao
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