EE 432- Control System Theory- 3 Hours
Elective Course

1. *2007-2008 Catalog description*
Linear, non-linear, and discrete automatic control systems: classical and modern control theory; computer-aided design and simulation. Prerequisites: senior standing in EE.

2. *Prerequisites by topics:*
a. Laplace and z transform analysis of linear systems.
b. Block diagram algebra and reduction.
c. Continuous-time systems modeling.
d. Root locus analysis and design.
e. Bode analysis and design.
f. Analysis of control systems with Matlab and Control System Toolbox software.

3. *Textbook(s) and/or other required material*
Required: EE 431 Lecture Workbook (700 pages), G. Dempsey
Recommended: Feedback Control Systems, 4th edition, Prentice-Hall, Phillips & Harbor.

4. *Class Schedule:* Three sessions per week, each 50 minutes, for 14 weeks

5. *Topics Covered (Outcomes influenced)*
Classical Controller Design:
- Frequency domain specifications (7 a,b)
- Lag, lead, lag-lead, PID compensation design in the frequency domain (7 a)
- Optimum phase margin design (phase versus frequency curve shaping) (7 b)
- Minor loop control, feed-forward compensation (7 c)
- Simulink, Control System Toolbox use in design process (7 a,b,c)

Sampled-Data Systems:
- Z-transform review, sampling operation, A/D and D/A converter and PWM modeling for sampled-data systems (7 d)
- Block diagram development and reductions of sampled-data systems (7 d,e)
- Steady-state error analysis (7 f,g,h)
- Stability analysis for sampled-data systems (7 g)
- s-plane to z-plane mapping, design regions in z-plane, z-plane frequency response, warping (7 g,h)
- Impulse, step, and ramp responses of closed-loop sampled-data systems (7 e)
- Control System Toolbox and Simulink use for sampled-data systems (7 f)
- Digital controller design: redesign methods (integration, differentiation, Tustin transformation, pre-warping) (7 h)
- Digital controller design: root locus in z-plane (7 h)
- Sampled-data system design examples: 100% digital, hybrid systems (7 d,h)

State-Variable Method:
- State-variable method for modeling physical systems (7 i)
- Linear algebra review for state-variable control (7 k)
- Design via pole placement, controllability (7 j)
- Observer design, observability (7 j,k)
- Control design using state-feedback and observer, separation principle for observer/controller design (7 j,k)

6. *Contribution of course to meeting the professional component*
Engineering science - 50%, Engineering Design - 50%

7. *Course Outcomes (Program Outcome contributions): In learning the course topics, the student will attain the following outcomes.*
a. The student will design analog controllers using frequency domain methods to meet specifications.
b. The student will design analog controllers using an optimum frequency domain method to meet specifications.
c. The student will design analog minor-loop and/or feed-forward controllers.
d. The student will develop control block diagram models for sampled-data systems.
e. The student will determine impulse, step, and ramp responses of sampled-data systems.

f. The student will use the Control System Toolbox to design, simulate and test sampled-data control systems.
g. The student will analyze systems to determine performance characteristics (control specifications) in the time and frequency domains for sampled-data systems.
h. The student will design digital controllers to meet specifications.
i. The student will use the state-variable method to model physical systems.
j. The student will design analog controllers using the pole placement method to meet specifications.
k. The student will analyze state-variable described systems using linear algebra methods (controllability, observability, state-space trajectories, etc.)

8. *Grading policy:* The degree to which students attain the course outcomes is determined by the following grading policy.
Homework 0% (22 assignments and 2 design project, used to determine borderline grades)
Test 1: 25% (closed-notes, 1 page equation sheet allowed)
Test 2: 25% (closed-notes, equation sheet provided)
Test 3: 25% (open-notes)
Test 4: 25% (open-notes)
The first two tests are closed-notes. Test 1 and 3 include material learned from the two design projects. The students will also complete a required reading assignment on a contemporary issue in the area of control theory. A one page summary of the findings is required. If the assignment is not completed by the day of Test 4, 5 points will be deducted from the Test 4 score. A grade of C corresponds to meeting the minimum competency required to understand course topics and meet course objectives.

9. *Relationship of course to program objectives*

label	Program Objective (A graduate from the program will)	Contribution
A	demonstrate knowledge of the mathematical and scientific foundation of electrical engineering.	Strong
B	demonstrate knowledge of and the ability to apply techniques and technology of electrical engineering.	Strong
C	complete a design project sequence, culminating in a capstone project at or near the professional level.	Moderate
D	understand that acquisition of new knowledge is needed for success in the electrical engineering profession.	Moderate
E	meet Bradley′s general education requirements which are based on the principles of liberal education.	NA
F	have experience in communicating technical information and working on teams.	Weak
G	understand the importance of professional and ethical behavior.	Moderate

10. *Prepared by:* Gary Dempsey 3/10/08