Course Number  EE 489  
Course Title  Control Theory  
Semester Offered Fall 2006  
Instructor  Hanshaw  
10th Day Enrollment 31  Number Completing Successfully (C grade or better) 27  

I. Assessment Outcomes from the Course Syllabus  

- (A) Ability to apply knowledge of mathematics, science and engineering.  
- (B) Ability to design and conduct experiments as well as analyze and interpret data.  
- (C) Ability to design a system, component, or process to meet desired needs.  
- (D) Ability to function on multidisciplinary teams.  
- (E) Ability to identify, formulate, and solve engineering problems.  
- (F) An understanding of professional and ethical responsibility.  
- (G) Ability to communicate effectively in written and oral formats.  
- (H) A broad education necessary to understand the impact of engineering solutions in global, economic, and societal context.  
- (I) Recognize the need for, and have the ability to engage in lifelong learning.  
- (J) Have a broad education and knowledge of contemporary issues.  
- (K) Ability to use techniques, skills and modern engineering tools necessary for engineering practices.  

II. List of Course Topics from the Course Syllabus  

1. The general concept of control system design  
2. Mathematical techniques for the control engineer  
3. Transfer function, block diagram, and signal flow graph  
4. State variable analysis, controllability, observability  
5. Control system stability  
6. Root locus techniques  
7. Time domain analysis and design  
8. Frequency domain analysis and design
### III. Course Assessment Summary Table: one row of the table should be devoted to each of the checked outcomes in part I.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Topics</th>
<th>Specific Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) Ability to apply knowledge of mathematics, science and engineering.</td>
<td>2-8</td>
<td>Homework assignments, exams, and final design project require application of math and science concepts.</td>
</tr>
<tr>
<td>(E) Ability to identify, formulate, and solve engineering problems.</td>
<td>1-8</td>
<td>The final design project was the primary measure for this outcome. The final design project required students to model a physical system and design and implement a compensator for the system.</td>
</tr>
<tr>
<td>(G) Ability to communicate effectively in written and oral formats.</td>
<td>1-8</td>
<td>Final project required a formal written project report and a short (5-10 minute) informal presentation.</td>
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<tr>
<td>(K) Ability to use techniques, skills and modern engineering tools necessary for engineering practices.</td>
<td>2-8</td>
<td>Most homework assignments and especially the final project required the use of MatLab to assist in system design and simulate system responses. Most students used Simulink in the final project to simulate nonlinear system responses.</td>
</tr>
</tbody>
</table>
IV. Using the table as a guide, for each outcome summarize your evaluation of the students’ achievement of that outcome; cite student performance on the identified measures as evidence to support your conclusions.

Background:
Examinations and homework assignments performed throughout the semester primarily functioned as vehicles to introduce specific course topics. The final class project required synthesis of overall course topics in the context of system modeling and compensator design.

The project this semester consisted of design and implementation of a motor speed control system. Course assessments from previous semesters have indicated that students may benefit from more “hands-on” exposure to control systems design, including an experimental or laboratory component to provide students with exposure to control system topics in a practical setting. Toward this end, a mechanical rotational system was constructed this semester in which the speed of a flywheel could be adjusted by varying the DC voltage applied to a motor. The final project for the class was to design a compensator to control the flywheel speed in this system to meet a set of design requirements. Design requirements included specifications on system type, rise time, and peak overshoot. Students were required to implement their compensator, test it on the physical system, and comment on differences between experimental and theoretical results.

Results:
The previously listed course criteria and the way in which they are addressed in the final project are discussed below.

(A) An ability to apply knowledge of mathematics, science and engineering:
Examinations, homework assignments, and the class project all addressed this ABET criterion. Overall, the majority of students displayed an adequate ability to apply concepts learned during the course. This was reflected by the high overall homework and examination averages. The average of the three midterm examinations was approximately 79% and the homework assignment average was 89%. The final exam required slightly more synthesis of the overall course material; the average score of the final exam was acceptable at approximately 77%.

One problem area was that some students had difficulty applying concepts learned in prerequisite courses. For example, the identification of parameters governing a first order system from measured step response data gave many students difficulty, even though the step response of a first order system is a concept that students should be familiar with from previous courses.
Although exams and homework assignments addressed this requirement to some extent, this ABET criteria was addressed primarily by the final design project. Students submitted three reports over the course of the design project: two interim reports and a final project report. The interim project reports were intended primarily to ensure that students were making progress on the project throughout the semester, and to provide the students with feedback relative to their designs and analyses prior to submission of the final project report.

The final design project required students to synthesize material learned in different portions of the class and pre-requisite classes in order to develop an appropriate compensator design. In general, the students had some difficulty in this area. This was indicated by the relatively low averages on the interim project reports – the overall average of the two interim reports was approximately 65%. Part of the reason for this low average appeared to be simple procrastination; many students simply did not allow themselves enough time to complete the project adequately. More problematic reasons for this low average score seemed to be a lack of familiarity with the overall design process and a lack of synthesis of material from previous courses and various parts of the current course. This shortcoming was overcome to some extent by the final project report submission; the average for the final project report was approximately 78%. It appeared that students had difficulty identifying and formulating the problem in an unfamiliar context, but could solve the problem readily once they had related the problem to concepts previously learned.

Compensator implementation also proved problematic for many students. Only six out of twenty seven students completing the course implemented a circuit which met all system requirements. Many students who were unable to implement a functioning circuit displayed inadequate problem-solving skills when confronted with hardware related issues. It appears that students are not receiving enough exposure to the implementation aspects of the overall engineering design process. This is the first semester in which compensator implementation has been required, so there are no metrics available to compare students’ performance this semester with previous semesters. Since this is the first semester in which compensator implementation has been required, the inability to construct a functioning circuit did not significantly penalize the students’ overall grade for the course.
(G) *Ability to communicate effectively in written and oral formats*

Both interim project reports consisted of a short written paper describing their principle results and conclusions. Most students could identify the important results, draw meaningful conclusions, and summarize these results well.

The final project required an in-depth write up of their results; the quality of these reports was highly variable. Most students displayed adequate to excellent written communication skills, but many of the reports tended to be poorly written, poorly organized, or both. It appeared that the students could identify the salient points of their analyses and design, but many were unable to provide a detailed and coherent discussion of their results.

Students were not penalized for poor reporting in this class.

The final design project submission also required students to informally present and demonstrate operation of their circuit to the instructor. Most students demonstrated adequate communication skills, at least in this informal setting.

(K) *Ability to use techniques, skills and modern engineering tools necessary for engineering practices*

Matlab was used to simulate system responses in most homework assignments. Both interim project reports and the final project required more in-depth use of Matlab to analyze engineering problems and perform system design. In general, students were enthusiastic about using Matlab for solving engineering problems. Their ability to critically review their numerical results was, however, somewhat inconsistent. Many students showed a strong desire to take the accuracy of any computer-generated results for granted.

Students used Simulink to simulate the system’s performance in the presence of nonlinearities in the form of saturation at the controller output. Again, students were readily able to perform the necessary analyses, but were less able to critically review their numerical results.
V. Qualitative Assessment of Student Performance: using the arguments above and other data support the claim that students who completed this course with a grade of C or better have achieved each of the intended outcomes of this course.

Overall, the students did very well on exams and homework assignments. The average score on the midterm exams was approximately approximately 79% and the homework assignment average was 89%. The final exam required slightly more synthesis of the overall course material; the average score of the final exam was acceptable at approximately 77%. Scores for the interim project reports were lower than desired; the average score for the interim project reports was approximately 65%. The final project report average was, however, acceptable at approximately 78%. This indicates adequate performance relative to the ABET criteria listed above.

VI. Concerns: state any concerns you may hold about this class – were the students adequately prepared coming into it? Are there topics or outcomes where (some) students were weak after completing the course? Other concerns? Were there any comments on students’ course evaluations that should be addressed in future instances of the course? This section is very important for improving our program: it provides critical input to the curriculum committee for identifying areas requiring attention.

Students were, in general, adequately prepared for the class before entering it. One problem appeared to be synthesis of materials from various previous classes, especially in the context of a design problem. Some deficiencies were noted in their abilities to use engineering analysis tools such as MatLab. Many of the skills associated with basic use of these tools were overcome during this class. Many students displayed inadequate abilities in the implementation of designs that they had created, and especially seemed to have difficulty debugging problems experienced during the implementation process. Students seemed to have a mind set that a circuit should perform according to expectations without additional modifications; they seemed to have few tools available to them to resolve differences between experimental and analytical results.

Many students had very poor writing abilities when coming into the class. To some extent, these skills were enhanced significantly during the class, but a number of students still displayed inadequate writing capabilities in their final project reports.

Students need more exposure to design problems and especially the implementation phase of the design process in this class and other concurrent classes.

Signature __________________________________________ Date: _______________________
