Washington State University
School of EECS
Electrical Engineering Course Assessment Report

Course Number EE 489
Course Title Introduction to Control Systems
Semester Offered Spring 2006
Instructor S. Roy
10th Day Enrollment 33 Number Completing Successfully (C grade or better) 29

I. Assessment Outcomes from the Course Syllabus

☒ (A) ABET Outcome: Ability to apply knowledge of mathematics, science and engineering.

Develop models for interesting physical systems; become fluent in representing models in standard form, in the state-space form, and in the Laplace domain; understand the notions of internal and BIBO stability, and be able to test for BIBO stability (including using the Routh criterion); be able to characterize the steady-state and transients of linear systems; be able to find transfer functions from block diagrams; learn to sketch root locus; understand the relationship between the forward-path frequency response and closed-loop stability/performance (including using the Routh criterion); gain time-domain insights into PID and lead-lag control of typical plants; understand some limitations of the control theory; briefly explore the differences between classical and modern control.

☒ (B) ABET Outcome: Ability to design and conduct experiments as well as analyze and interpret data.

Use experimentally-obtained frequency response data to design a controller for the plant.

☒ (G) ABET Outcome: Ability to communicate effectively in written and oral formats.

Communicate effectively via a written project report and through informal project demonstrations.
(C) ABET Outcome: Ability to design a system, component, or process to meet desired needs:

Use root loci to design controller to meet transient and steady-state specifications; design and analyze high-performance compensators given plant frequency responses.

(D) ABET Outcome: Ability to function on multidisciplinary teams.

(E) ABET Outcome: Ability to identify, formulate, and solve engineering problems.

Learn to develop a linear and/or non-linear system model for an experimentally-studied physical system, learn to develop and implement optimal controllers for a simulated plant.

(F) ABET Outcome: An understanding of professional and ethical responsibility.

(I) ABET Outcome: Recognize the need for, and have the ability to engage in lifelong learning.

(J) ABET Outcome: Have a broad education and knowledge of contemporary issues

(K) ABET Outcome: Ability to use techniques, skills and modern engineering tools necessary for engineering practices.

Ability to design and implement computer programs to simulate linear systems and design/implement controllers for them.

II. List of Course Topics from the Course Syllabus

1. Introduction to Control Systems. (3 hours)

2. Modeling of electrical, mechanical, and heat and fluid flow systems. (9 hours)

3. Forms for differential equations: standard form, state-space form, and Laplace domain (2 hours)

4. Pre-analysis: linearization, scaling (2 hours)

5. Analysis of linear systems: finding solutions, internal and BIBO stability, steady-state, and transient performance. (8 hours)

6. Analysis of feedback control systems (block-diagram analysis, stability and steady-state analysis for standard configurations, time-domain insight into PID and lead-lag compensators). (7 hours)
7. Root locus design: sketching and interpreting loci (7 hours)

8. Frequency response-based design of lead/lag and other controllers (7 hours)

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 (Samples should be available in the course materials file for inspection.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) ABET Outcome: Ability to apply knowledge of mathematics, science and engineering.</td>
<td>1-8</td>
<td>Homework exercises, computer exercises, projects, exams</td>
</tr>
<tr>
<td>(B) ABET Outcome: Ability to design and conduct experiments as well as analyze and interpret data.</td>
<td>8</td>
<td>HW 9 and 10, design project, Final Exam Problem 3</td>
</tr>
<tr>
<td>(C) ABET Outcome: Ability to design a system, component, or process to meet desired needs.</td>
<td>7,8</td>
<td>HW 7-10, exam 3, final, projects</td>
</tr>
<tr>
<td>(E) ABET Outcome: Ability to identify, formulate, and solve engineering problems.</td>
<td>2,7,8</td>
<td>Modeling and design projects</td>
</tr>
<tr>
<td>(G) ABET Outcome: Ability to communicate effectively in written and oral formats.</td>
<td>1-8</td>
<td>Project reports, selected test questions</td>
</tr>
<tr>
<td>(K) ABET Outcome: Ability to use techniques, skills and modern engineering tools necessary for engineering practices.</td>
<td>3-8</td>
<td>HW 6-10, modeling and design projects</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.

(A) Ability to apply knowledge of mathematics, science and engineering.
All passing students achieved this outcome, as evidenced by their responses and performance on homework and exams, as well as their work on both the modeling and design project.

(B) Ability to design and conduct experiments as well as analyze and interpret data.
The students achieved the analysis and interpretation of data, as evidenced by their efforts in using frequency domain design techniques in certain problems on HW 9 and 10, and on the final exam. The ability to design and conduct experiments was not stressed in the course, though many students did rigorous experimental work for the modeling project.

(C) Ability to design a system, component, or process to meet desired needs.
A plethora of exam, homework, and project work from the design component of the course (problems connected with root-locus and frequency response-based design demonstrate that students achieved this criterion.

(E) Ability to identify, formulate, and solve engineering problems.
The students’ work on both the modeling and the design project, as well as on some broader final-exam problems, demonstrate their ability to solve engineering problems. The design project was also designed so that students would need to formulate and engineering project, and their work on this project suggests that they succeeded. We stress here that problem identification was not significantly addressed in this class.

(G) Ability to communicate effectively in written and oral formats.
The students’ written reports for both projects, as well as their ability to discuss their work and answer the instructor’s questions during the design project demonstration, highlight their ability to communicate effectively in written and oral formats.

(K) Ability to use techniques, skills and modern engineering tools necessary for engineering practices.
All students used the Matlab simulation program for homework assignments and projects, and also were tested on use of Matlab on the final.
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.

We strongly believe that students who completed this course with a grade of C or better have achieved the intended ABET outcomes for this course. Our discussion of each outcome above supports that all students have been given multiple opportunities to demonstrate their competence in each area above, and have had to demonstrate competence in order to pass the class. The students’ achievement of the outcomes is reflected, especially, by their work on the final exam in the class. In particular, the students have demonstrated through the final that they are able to assimilate notions from various parts of the course, indicating that they have gained the perspective on the subject required by ABET, and not simply a procedural understanding of topics in the field.

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.

I have two main concerns regarding the course.

1. I felt that a subset of the students were not adequately prepared, in terms of their background in mathematics and especially in terms of their “mathematical maturity”. For instance, when I asked students to prove one of the root-locus rules on a homework set, nearly all the students mentioned that they had little experience in composing proofs. I also felt that students’ conceptual understanding of certain topics, such as the notion of a frequency response or even the representation of a system as a differential equation, was lacking.

2. Several students mentioned to me that they would be interested in a Controls Laboratory course, or a subsequent course on Digital Control or Robotics. As resources permit, it would be worthwhile to put in place an elective course on Control Theory that addresses some of these topics.

Signature __________________________________________ Date: _______________________

Please email a copy of the completed form to Patricia Arnold, patricia@eecs.wsu.edu and deliver a signed hardcopy to her mailbox.