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 life long 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. Laboratory and equipment familiarization
2. Operational Amplifiers – characteristics and filters
3. Diode characteristics, PSPICE, and circuits
4. BJT characteristics, model and circuits
5. MOSFET characteristics and circuits
6. Circuit analysis: steady state and transient behavior of RLC networks, frequency response
7. Design project
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>1-7</td>
<td>Laboratory assignments, pre-labs, and <strong>final design project</strong> require application of math and science concepts.</td>
</tr>
<tr>
<td>(B) Ability to design and conduct experiments as well as analyze and interpret data.</td>
<td>2-7</td>
<td>All lab assignments require students to acquire and analyze experimental data. <strong>Final design project</strong> requires students to design experiments necessary to characterize the system.</td>
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<tr>
<td>(C) Ability to design a system, component, or process to meet desired needs.</td>
<td>7</td>
<td>Several lab assignments require simple design projects; <strong>final design project</strong> requires an in-depth, top-down design based on specifications provided by instructor.</td>
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<tr>
<td>(D) Ability to function on multidisciplinary teams.</td>
<td>7</td>
<td><strong>Final design project</strong> required knowledge of mechanical subsystem.</td>
</tr>
<tr>
<td>(G) Ability to communicate effectively in written and oral formats.</td>
<td>2-7</td>
<td>Most laboratory assignments required demonstrations to TAs and written reports. <strong>Final project</strong> required a short (10-15 minute) informal presentation and a formal written project report.</td>
</tr>
<tr>
<td>(J) Have a broad education and knowledge of contemporary issues.</td>
<td>2-7</td>
<td>Students are exposed to a wide range of electronics-related topics; <strong>final design project</strong> required design of control system.</td>
</tr>
<tr>
<td>(K) Ability to use techniques, skills and modern engineering tools necessary for engineering practices.</td>
<td>2-7</td>
<td>Most laboratory assignments and especially the <strong>final project</strong> require use of typical laboratory bench equipment (oscilloscope, function generator, etc.) and computer analysis tools (PSPICE, MATLAB).</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.

Successful completion of all outcomes was evaluated based primarily on the final class project; individual laboratory assignments performed throughout the semester primarily functioned as vehicles to introduce specific topics which were necessary for successful completion of the final design project. The project this semester consisted of design and implementation of a temperature control system. A Peltier junction was used to provide a heat flux to a heat sink; students controlled the heat rate by controlling the current applied to the Peltier junction. Specifically, the students were required to design and implement the following subsystems:

1. Temperature measurement system – the students were required to use a thermistor as a basis for a system which would output a DC voltage which was approximately proportional to the heat sink temperature.
2. Controller – the students were required to control the heat rate from the Peltier junction. The controller input was the difference between a desired and actual temperature, and the controller output was the current applied to the Peltier junction.

Nominally, students worked in groups of two during the design project.

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:

Overall, the majority of students displayed an adequate ability to apply concepts learned during the course. Some students, however, had difficulty applying concepts learned in pre-requisite and co-requisite courses.

(B) Ability to design and conduct experiments as well as analyze and interpret data:

All lab assignments required students to conduct experiments, gather, and interpret data. Several lab assignments required students to design circuits to perform a specified task; generally, in the laboratory assignments, the design objectives were closely related to current course material. The final project allowed students more latitude in the experiments they performed; in general, it was entirely up to the students to design and conduct any experiments they deemed necessary to perform the design process at hand and demonstrate that the resulting design met requirements.

As expected, few students had little difficulty conducting experiments with instructions which outlined step-by-step approaches to building a circuit and acquiring data. Design tasks contained within individual lab assignments gave the students only slightly more
difficulty, probably because of the focused nature of the problem. As expected, the design project, though not difficult, gave the students the most difficulty. This was primarily due to the fact that the students needed to identify and formulate a problem in a relatively unfamiliar context, and that the project required students to synthesize material learned throughout the course. Students were generally able to solve the problem readily once some “hints” were provided as to how to relate the problem to concepts learned previously in the course. The fact that the design project introduced the necessity of analyzing a non-electrical component gave the students some difficulty, though the difficulty level was more perceived rather than actual. One problem area was that students tended to avoid acquiring data until after implementing their design.

(C) *Ability to design a system, component, or process to meet desired needs.*

The final project required students to design a system to control the temperature of a heat sink by controlling the current applied to a Peltier junction. Virtually all students were able to design a system which met requirements. The students’ analysis of the system was considerably improved over previous semesters, primarily due to the addition of an interim design report. The interim design report required students to complete several key analyses prior to finalizing their designs, and allowed the instructor to provide feedback and mid-course corrections relative to these analyses.

(D) *Ability to function on multidisciplinary teams*

Students in the class are all electrical engineering students. The multidisciplinary aspect of the class was incorporated in the final design project. The project included a significant mechanical system component. The instructor acted as mechanical engineer for all groups; he performed tasks relative to modeling of the thermal aspects of the problem and performed in a role which would typically be held by a mechanical engineer in a multidisciplinary team.

(G) *Ability to communicate effectively in written and oral formats*

Individual lab assignments required submission of a lab report; this resulted in submission of ten semi-formal reports over the course of the semester. These lab reports were not stringently graded, the overall idea was to give students some practice in organizing their results prior to submission of the final, formal design project report. Grading criteria for these reports were explicitly provided. In general, performance on the individual lab reports was good.

Performance on the final design project report was excellent. Most students did an outstanding job of organizing and presenting their results; it is felt that this improvement over previous semesters’ performance was primarily due to the addition of an interim design report requirement. In addition to the technical benefits noted above, the interim design report allowed the instructor to provide feedback to the students relative to writing style and organization.
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.

\textit{(J) Have a broad education and knowledge of contemporary issues}

The final design project introduced students to some basic issues in the field of controls. A brief introduction to feedback control was provided, as were the basics of PID control. The field of system identification and model parameter estimation was also introduced obliquely, as students were encouraged to acquire step response data for their systems in order to identify the appropriate parameters with which to model their system.

\textit{K) Ability to use techniques, skills and modern engineering tools necessary for engineering practices}

The final project required a significant level of analysis, including simulation of their overall closed-loop control system. Students were allowed to choose either MatLab or PSPICE to simulate their systems. Students almost invariably chose MatLab to simulate the overall system, probably because of the inclusion of the thermal system components in the overall system. Some students used PSPICE to simulate their electrical subsystems, but resorted to MatLab to simulate the overall system.

Many students used Simulink to simulate the system’s performance, in order to readily analyze saturation effects in the system. This was very encouraging, since Simulink was not an analysis approach recommended a priori by the instructor. Students were apparently able to recognize the nonlinearities and attempt to incorporate them in their analysis.

\textbf{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’ performance was good. The average score on the laboratory assignments was very high, at approximately 86%. The average for the final project report was also very high, at approximately 86%. The improvement in the final project scores over last semester is attributed primarily to the addition of an interim design report requirement.

The students’ proficiency with MatLab and PSPICE was, in many cases, lower than expected.
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. Some deficiencies were noted in their abilities to use engineering analysis tools such as MatLab and PSPICE. PSPICE skills, in particular, were poor. Students felt dissatisfied with the PSPICE presentation in the sophomore-level circuits lab (EE 262). Many of the skills associated with basic use of these tools were overcome during this class. It is recommended that additional PSPICE instructional materials be provided during the early part of the semester in EE 352 to assist in overcoming these shortcomings.

Many students had very poor writing abilities when coming into the class. For the most part, these skills were enhanced significantly during the class.

Students need more exposure to design problems in this class and other concurrent classes.

Signature __________________________________________ Date: _______________________

Signature __________________________________________ Date: _______________________