**Abstract** – Modern electrical engineering services courses for the other engineering majors have expanded beyond simply providing coverage of basic electrical topics to prepare students for the FE exam. These junior and senior students soon afterwards will also be applying electrical concepts for instrumentation and measurement within their other engineering courses. In Fall 07, 65 civil and architectural students in an EE service course identified the need for mini-cases in the areas of resistance strain gauges, transducers involving capacitors, power systems, and amplifiers. In Spring 08, 125 mechanical and aerospace engineering students in another EE service course focused on force measurements using Wheatstone bridges, digital position encoders, EPROM-based lookup tables, and electronic controllers. A block of material on electrical circuits is common between the two courses. Student-driven mini-cases are being prepared during the summer for class testing during Fall 08, and others will be developed in the fall for Spring 09. Results including student assessments for several of these mini-cases will be reported at FIE 08. Preliminary mini-case details on distinct materials covered in the separate service courses will also be available at FIE 08.

**Index Terms** – EE service courses, extended applications, mini-case studies, student-driven applications.

**INTRODUCTION**

EE service courses commonly provide a brief introduction to electrical engineering topics for engineering majors outside of electrical and computer engineering departments. While electric circuits is always a focus during the first several weeks in an EE service course, a variety of other topics, often in cursory form, are also included later in the course. In fact, textbooks are written especially for the EE services courses [1]; these generally only briefly cover topics found in several detailed textbooks in electrical and computer engineering courses. The EE service courses are not to be taken by electrical and computer engineering majors. In contrast, courses in thermodynamics, statics, strength of materials, and dynamics are taught in the other engineering departments both for their own majors, such as mechanical or civil engineering students, and for electrical and computer engineering majors. As such, these courses are not regarded as service courses but as required courses for their own engineering majors, and they are often taught by tenured or tenure-track professors in those departments. EE service courses, often considered a less desirable teaching assignment, are sometimes taught by adjunct faculty or by PhD students who aspire to become professors after completing their degree requirements and want the early experience of teaching an engineering class.

This paper is the third (and final) WIP paper describing improvements in the EE service courses at the University of Kansas. Presented at FIE 06, the first paper [2] described the reorganization of a single four-hour EE service course into two different three-hour courses, one for civil and architectural engineering majors and the other for mechanical and aerospace engineering majors. A few engineering physics and chemical or petroleum engineering students also take one of the courses. A separate one-hour lab on electronics and instrumentation is offered in Spring semesters. The second paper [3], presented in a lively FIE 07 session late in the conference, described a highly successful motivational strategy in these large EE service classes (83 in Spring 07, 65 in Fall 07). This third WIP paper for FIE 08 describes how both EE service courses are responding to the student-driven demands for extended mini-cases especially applicable to their own engineering majors. A full paper is planned for FIE 09; it will describe the role of the associated lab in Spring semesters and will specifically focus on whether this lab has a significant positive influence on student learning. Learning patterns and achievements in the two EE service courses (with and without the lab) will be examined and compared.

**REQUESTS FOR EXTENDED APPLICATIONS**

The objective of special assignments in Fall 07 and Spring 08 was to encourage students to think beyond what had been presented in the classroom and reading assignments and to suggest meaningful extended applications in their engineering majors. It was observed that if even a few of those suggestions could be developed further by the professor into mini-case packets, the results can be a significant course improvement. The concepts are different from topics in the associated lab.

An appeal with regard to course goals was made to the students. A primary goal had been to provide a background in electrical engineering concepts that allows them to extend further in courses within their majors. A second goal had been to provide basic electrical circuits concepts that help to prepare for the Fundamentals of Engineering (FE) exam. A third goal being suggested was to use mini-case studies in the electrical area to demonstrate extended applications that are most pertinent in their majors. Additional instructions given to the students were for them first to consider some of the
topics in the textbook [1] under “Focus on Measurements” listings and then to find other topics on the Internet.

**SUGGESTED MINI-CASES IDENTIFIED BY STUDENTS**

Table I lists the top five topics suggested by the 65 civil and architectural engineering students in Fall 07 and the top five by the 125 mechanical and aerospace engineering students in Spring 08. From 6 to 15 other specialized topics were also suggested in the two semesters. Students had been asked to work in teams of two but some chose to work alone. One team interviewed three mechanical engineering professors who each highly recommended both the strain gauge and Wheatstone bridge mini-cases. Moreover, requesting student inputs to help in selecting mini-cases provided another advantage; some reported that they had reservations previously about whether electrical concepts were important at all in their majors but had become convinced of their value after considering their extended applications. Resistance strain gauges and Wheatstone bridges for force measurements are planned mini-cases for both EECS 315 and 316, while other topics appear to be appropriate for only one of these service courses.

**TABLE I**
**EXTENDED APPLICATIONS SUGGESTED BY STUDENTS**

<table>
<thead>
<tr>
<th>Topics</th>
<th>No. of Teams</th>
</tr>
</thead>
<tbody>
<tr>
<td>EECS 315</td>
<td>Resistance Strain Gauges</td>
</tr>
<tr>
<td>Fall 07</td>
<td>Wheatstone bridges for measuring forces</td>
</tr>
<tr>
<td>Transducers using capacitors</td>
<td>6</td>
</tr>
<tr>
<td>Power systems</td>
<td>5</td>
</tr>
<tr>
<td>Amplifiers (EKG, filters)</td>
<td>4</td>
</tr>
<tr>
<td>EECS 316</td>
<td>Resistance Strain Gauges</td>
</tr>
<tr>
<td>Spring 08</td>
<td>Wheatstone bridges for measuring forces</td>
</tr>
<tr>
<td>Digital position encoders</td>
<td>8</td>
</tr>
<tr>
<td>EPROM-based lookup tables</td>
<td>7</td>
</tr>
<tr>
<td>Electronic controllers</td>
<td>7</td>
</tr>
</tbody>
</table>

In preparing min-cases for presentation to the students, the following guidelines are being followed.

- PowerPoint presentations are prepared in advance on the selected topic.
- The in-class presentation should be scheduled for a time period of 15 to 20 minutes, including questions.
- The mini-case is an extended application of basic concepts that have already been covered in class, homework, and short quizzes. As such, the date of presentation should be within 2 to 3 weeks after the materials are first introduced in the course. Since some topics other than electric circuits are covered in only one of the two service courses, mini-cases for those concepts can be presented only in one course.
- Handout materials, including PowerPoint copies, are made available for distribution.
- Hardware demonstrations are planned.
- Forms for student assessment are distributed.

**MINI-CASE NO. 1: RESISTANCE STRAIN GAUGES**

Strain gauges measure not only strain, but also stress, force, torque, and pressure. The first step was showing that resistance of a strain gauge bonded to the surface of an object is linearly related to the strain over a small percentage range. Next, identify the allowable range of operation for a typical foil strain gauge. Show a metal-foil resistance strain gauge and describe how it was constructed. Finally, include a tour of the civil engineering labs with on-site descriptions from the lab technician.

**MINI-CASE NO. 2: WHEATSTONE BRIDGES**

An application of strain gauges is the measurement of the force applied to a cantilever beam. Four strain gauges are used in a Wheatstone bridge configuration. The first step is showing that the four resistances, two bonded to the upper surface and the other two to the lower surface, do indeed yield a linear relationship between the output voltage and the force applied to the beam. Next, a Wheatstone bridge analysis, possibly in conjunction with Thevenin’s equivalent circuit, justifies the theoretical concept. Specific applications for mechanical, aerospace, civil, architectural, chemical, and biomedical engineering are identified. Finally, another visit to the civil engineering labs can show demonstrations of force measurements on cantilever beams.

**MINI-CASE NO. 3: EPROM-BASED LOOKUP TABLES**

A lookup table for automotive fuel injection system control is simply an input-output table that circumvents the need to compute functions using an algorithm. The mass airflow into the system is sampled and converted from an analog to a digital signal; this digital value is passed through the lookup table to yield a desired fuel injector pulse width. Next, data is obtained for the table from the underlying algorithm, and the table itself is constructed. Technical details that describe how the lookup procedure is employed are presented, and any practical limitations are described. Schematic diagrams of the use of the EPROM-based table are presented, and the lookup table itself is shown.

**CONCLUSIONS**

The idea of student-driven mini-case studies appears to be a valuable addition to the EE service courses. As a work-in-progress, mini-cases are being developed for Fall 08 and Spring 09. Results for mini-cases on common materials between the two courses, including some student assessments for Fall 08, will be reported at FIE 08. Preliminary mini-case details on distinct materials covered in the separate service courses will also be available at FIE 08.

**REFERENCES**

