Has this Embedded System Design course been taught at CU in the past?

The Embedded System Design course was offered for the first time during the fall of 1999. During the Spring 2000 semester, the course was substantially improved and was offered for the first time through Continuing Education. Student feedback has been incorporated into the course design, and the course format has been modified to fit the needs of Continuing Education students better. The course is further refined each semester it is offered. The course has been described by students as valuable, fun, and challenging.

When will this class meet and is attendance required?

During the Fall 2003 semester, ECEN 5613 will meet on Wednesday evenings from 5:00pm-7:30pm. Attendance and class participation is expected from all students. It is understood that time conflicts may prevent a student from attending every class. In the event that a class is missed, it is the student's responsibility to obtain handouts or notes from that class. Most class materials will be posted on the course web site. Note: many of the campus parking lots are free after 5:00pm.

What is the scope of this course? Will class members need to work in teams? Will there be lab work that must be done on campus?

Embedded System Design is focused at the fundamentals of embedded system design, and is meant to give students experience in both hardware and firmware. As the first course in the Embedded Systems Certificate Program, it is meant to provide a foundation of knowledge for students to utilize in future embedded systems courses and in their professional work environments. For the student who already has significant hardware and firmware experience, the course offers a framework within which the student can pursue an embedded systems project of interest to that student. Experienced engineers who are looking solely for a project-focused course may find the Embedded Systems Laboratory Project Design course more appropriate for their needs.

As far as the laboratory is concerned, the course is centered around the design and construction of an embedded system by each student, utilizing the 8051 microcontroller and an 8051 assembler and C compiler. Students are required to demonstrate that their hardware works in the on-campus laboratory, and must demonstrate that they know how to use an oscilloscope and logic analyzer to debug their systems. The software tools, test equipment, and EPROM programmer and eraser are available in the lab.

Students who prefer to work off-campus can obtain a free demo version of the Emily52 simulator and ASM51 assembler or can purchase the DDS MICRO-C 8051 developer's kit (including an 8051 C cross compiler, 8051 cross assembler, and 8051 monitor) for $99.95 plus shipping from http://www.dunfield.com. Also available is the Emily52 simulator ($49.95), which can be used to debug code before hardware is available. Note: If you order, you may want to order from a Denver distributor or have the software shipped by FedEx if you order directly from Dunfield Development Systems (located in Canada); otherwise, it may not arrive in time for the course. Remember, free demo versions of the ASM51 8051 cross assembler and the Emily52 simulator are available at the Dunfield web site. Students can fully develop their hardware off-campus using the class parts kit, if they have their own soldering iron (students may sign out a wire wrap tool for the semester). Additionally, students can learn how to debug their systems off-campus, if they have access to a +5V DC power supply (a small +9V DC, 1200 mA wall adapter is sufficient) and optionally, a logic analyzer. Communication to the hardware can be done with a simple RS-232 connection and a terminal emulator program running on a host computer. An 8051 monitor program will be provided to students to aid in debugging hardware and firmware. Students who are comfortable with hardware and software design and debugging should be able to complete their assignments with a relatively small amount of time on-campus outside of class. On-campus time would include learning how to program an EPROM and getting hardware to run with code stored in that EPROM, as well as demonstrating knowledge of how to use the logic analyzer to debug microcontroller hardware, and demonstrating to the instructor or the TA that student-built hardware works.
The majority of the course will be taught using data sheets, application notes, and article reprints. In addition, notes and assignments will be provided to guide the students through the material. Several embedded systems books have been placed on reserve in the engineering library on campus. A formal text is not required for the course in addition to these materials; however, a list of recommended books will be provided with the course syllabus.

During the first half of the course, students will individually develop similar hardware platforms and firmware. Due to the common design of the hardware platforms, students can benefit from the experiences of other students in the class. Sharing of knowledge between students is highly encouraged; however, each student is expected to implement his/her own hardware and firmware. Students are encouraged to help other students solve problems, since significant learning can result from such activities. Students may find that they are able to leverage hardware or firmware designs from books, magazines, the Internet, or their work environments; however, in these cases, students are expected to credit the source of the information. Plagiarism is not acceptable.

The scope of the course projects has changed as a result of feedback from the students in the class in fall 1999, where students spent approximately 1/3 of the semester on group projects. The course now includes an additional hardware/firmware assignment prior to the final project. As a result, the final project will only encompass 25% of the course. Since it may be difficult for students taking the course to get together to work on team projects, students will be given the option to complete individual final projects if desired. If students prefer to work in teams, groups of up to three students will be allowed. As examples of past projects, student teams have developed a device programmer, a graphic calculator, a multi-player tank battle game, an embedded operating system, an automated checkers game, a small mobile robot, a motor controller, a remote control billboard display, an MP3 player with compact flash memory interface, a USB device, a wireless pager, and a home security system. Final projects will be presented during the last class period.

A preliminary syllabus will be posted on the course web site. The course will be a blend of hardware and firmware issues. Weekly lecture topics will parallel the hardware and firmware assignments, and will be scheduled to enable each student to develop a functional basic embedded system within the first six weeks of the class. Students enrolling in the class will be encouraged to start reading the data sheets for the 8051 processor before the class starts, as the schedule for the class will be somewhat challenging.

**I haven't done hardware (software) design for a long time. Will I be able to complete this course successfully?**

In order for a student to be successful in the course, the most important things are that the student has a good engineering background, an interest in the material, and a high level of motivation. Much of the course learning comes from the actual implementation of the hardware and firmware by each student. Although the implementation is challenging for some students, feedback from former students has indicated that the act of going through all the steps in the implementation has provided them a learning experience unmatched by pure theory courses. The complexity of the C programming required for success in the course is not great; however, all students are encouraged to review the basics of C and assembly programming before the class starts. In addition, students are highly encouraged to review basic EE concepts such as Ohm's law, RC circuits, digital logic, and basic microprocessor architecture before the course begins. This course will focus on the fundamentals of embedded systems, so extensive hardware or firmware knowledge is not a prerequisite for the course. However, the amount of material covered in the course is substantial, and students who are weak in one or more of the prerequisites may find the course difficult. The limited amount of instructor and TA office hour time will be shared among all the students in the class and may not be monopolized by a student who does not possess the prerequisite knowledge. It is common for students in this class to have diverse backgrounds, and for students with strengths in particular areas to share information and to work with students who have complementary strengths. Former students with backgrounds specific to software or to analog/digital electronics have successfully completed this course, and have commented that one of the best things about the course is that it gave them exposure to and experience in a technical area in which they were not strong.
**I work full time. How will I be able to get help in this class?**

The instructor also has a full time job as a computer design engineer at HP in Fort Collins and understands the challenges of managing professional, academic, and personal commitments. Efforts will be made to clearly describe assignments to minimize student confusion. The instructor will hold office hours immediately after class on Wednesday nights, and at another time mutually acceptable to the instructor and the class (most likely on Saturdays). A graduate teaching assistant (TA) will be available to assist students in the lab and to answer questions by e-mail. The instructor will also periodically distribute e-mail with information useful to the class, and will answer questions by e-mail in the event that the TA is not available.

**About how many hours of work per week can be expected for this course?**

This is a standard 16-week semester, 3 credit hour course. Average students with the prerequisite background can expect to spend 8-16 hours per week on the course, depending on their individual capabilities and the grade they would like to earn in the course. It is expected that this class will be a priority for students; however, it is understood that it is impossible for this class to be the top priority for all students due to their work and personal/family responsibilities. Efforts will be made to distribute assignments far in advance of the due date to allow students to fit this workload into their schedules. There will not be a final exam for this class.

**What is the grading criteria for the class?**

The normal CU grading standards as shown below will be applied to this class.

- **A** Superior, outstanding
- **A-**
- **B+** Above average
- **B-**
- **C+** Average, has adequately met course requirements
- **C-**
- **D+**
- **D-** Minimum passing grade
- **F** Fail, has not met course requirements

ECEN 5613 is a graduate level class, and expectations for students will be high. Student performance in this class will be compared to student performance across ECE graduate classes. A grade of 'A' will be reserved for students who have delivered outstanding work and who have clearly demonstrated a superior mastery of the course material. The majority of each student's course grade will be determined by the quality of the hardware and firmware assignments and the final project completed by the student during the semester.

**How do the three courses in the Embedded Systems Certificate Program fit together?**

The Department of Electrical and Computer Engineering has begun a certificate program in embedded systems. To obtain a certificate, students must successfully complete three embedded systems courses, consisting of two core courses and one elective course. The first core course is ECEN 4613/5613 Embedded System Design, in which students are exposed to the fundamentals of embedded systems and get experience in developing hardware and firmware around the popular 8-bit 8051 microcontroller. In the second core course, ECEN 4623/5623 Real-Time Embedded Systems, students learn real-time theory and gain experience in developing code using the popular VxWorks real-time operating system and various 32-bit targets along with the PCI bus.

Students may choose the third course from a set of approved electives. Currently, the approved electives include ECEN 4033/5033 Software Engineering of Stand-Alone Programs, and ECEN 4633/5633 Embedded Systems Laboratory (currently being redesigned). Students are encouraged to take ECEN 4033/5033 prior to ECEN 4623/5623 in order to maximize leverage of software engineering concepts.
What grades in the Embedded System Design class will count toward the embedded systems certificate?

Students may take this course for credit with standard 'A'-'F' grading, for credit with 'pass/fail' grading, or for no credit. This course will count toward the embedded systems certificate only for students who take the course for credit and earn a passing grade of 'C' or better.

Counts toward certificate
- Grade of 'C' or higher

Does not count toward certificate
- Grade of 'C-' or lower
- Grade of 'pass' or 'fail'
- No credit

What materials are required for the class?

Students will need a parts kit, which will be distributed in the first few weeks of the semester. The cost of the parts kit is included in the tuition paid to Continuing Education. Additional parts required for student projects and optional text books will also be the financial responsibility of the student. Data sheets and application notes will be freely available via the Internet. The software development tools will be available on the computers in the Embedded Systems Laboratory. If students want to purchase a copy of the tools for use at home or work, they are welcome to order directly from the developer. Electronic keys for lab access, digital logic probes, and assembler/compiler/tool documentation will be checked out to each student and will be collected at the end of the semester. Computers, lab stations, logic analyzers, oscilloscopes, power supplies, device programmers, EPROM erasers, and a printer will be available in the on-campus lab.

I see that ECEN 5613 is offered through Continuing Education and the ECE Department on alternating semesters. How do these two versions of the course differ?

These days, the two versions of the course have fewer differences than when the course was first offered several semesters ago. The major differences are:

1. Registration priority differs. Students from industry have priority for the Continuing Education version of the course. Full-time degree-seeking students have priority for the regular version of the course.
2. The parts kit is included in the tuition for the Continuing Education version of the course, but is purchased separately for the regular version of the course.
3. An attempt is made to have more TA help available on the weekends for the Continuing Education version of the course, since students from industry tend to use the weekends to complete much of the course work, while full-time students prefer weekdays.
4. Continuing Education students may be expected to print out more of the data sheets rather than have them handed out in class.
5. Following the normal academic calendar is not a firm requirement for courses offered through Continuing Education, although an attempt is made to follow the normal academic calendar to enable full-time students to take the class.

Where can I find on-line information related to this Embedded System Design course?

The primary course web site can be found on the instructor's ECE web page at:

http://ece-www.colorado.edu/~mcclurel/index.html

This primary course web site will be updated often throughout the semester. Students will be able to obtain course information and documentation from this site. This web site includes links to many other useful web sites related to embedded systems, including the Continuing Education web site.