USC Viterbi School of Engineering

Ming Hsieh Department of Electrical and Computer Engineering

EE 459Lx - Embedded Systems Design Laboratory

Syllabus for EE 459Lx – Spring 2025

(Section 30598 - 2:00-3:50 TTh)

General Information

Instructor:	Prof. Allan Weber	Lecture Room:	?
Office:	EEB 410	Lecture Times:	2:00-3:50 TTh
Email:	weber@usc.edu	Lab Room:	OHE 240
Office Phone:	213-740-4147	Lab Times:	as needed
Office Hours:	M: 10-11:30, W: 11-12, Th: 4-5		

Class web site: https://ece-classes.usc.edu/ee459

Goals

This is a Capstone design course for seniors majoring in Electrical and Computer Engineering (ECE) or Computer Engineering/Computer Science (CECS). Students will work in teams to do a hardware/software project under the supervision of the instructor. The teams will be entirely responsible for all aspects of the project design process. This will involve the specification, design, implementation, testing and documentation of a digital system project using embedded processors, programmable logic, analog I/O interfaces and application specific hardware. During the semester the teams will be required to:

- Meet with their teammates to decide what product to build according to the guidelines provided.
- Write a proposal describing what the team plans to build including a development timeline.
- Determine what engineering standards apply to this product and how your design will make use of them and be in compliance.
- Do an initial design of the product using CAD tools or on paper.
- Determine what parts will be required and select vendors.
- Do an oral Detailed Design Review presentation to the class.
- Finalize the design of the product, both hardware and software.
- Construct and debug the prototype in the EE 459Lx lab (OHE 240.)
- Demonstrate their product prototype to the instructor and other students.
- Do an oral presentation to the class on the technical details of their product.
- Submit a written report on the product including circuit diagrams, software listings and an analysis of the cost of manufacturing the product in large quantities.

Learning Objectives

This class gives the students an opportunity to bring together skills and knowledge they have learned in several other classes to give the student an experience that is similar to what they might encounter when employed as a design engineer. Students will learn the following.

- How to design a moderately complex digital system based on a programmable microcontroler
- How to read component datasheets to determine whether they will do the operations needed.
- How to work with multiple teammates: organizing and scheduling the required tasks and maintaining lines of communication.
- How to integrate all the parts of the project into a single system.

This course is not just about designing and building a project. It is also about managing the process of completing it on schedule. Teams are expected to work on the project throughout the semester and to have contingency plans if things don't go as expected. For example, what do you do if some component you were depending on using is not available or it doesn't work the way you thought it would? All teams are strongly encouraged to work on the project in such a way that they don't have to rush to acquire and assemble all the parts at the last minute.

Prerequisite

Students must have taken EE354 (Introduction to Digital Circuits). Equivalent courses may be accepted if approved by the instructor.

Recommended Preparation

The microcontrollers used in the project are programmed with the "C" programming language. Students should be proficient in writing moderately complex programs C. Having taken a programming class like EE 155 or CS 103 is recommended.

Course Notes

Course is graded on a letter-grade basis. This is a project course with no textbook, homeworks or exams. For the first few weeks the class will meet in the assigned lecture room for lectures on project related topics and for teammates to brainstorm project ideas, or in the lab facility to discuss lab safety, tool usage and project construction techniques. After that there will only be a few class meetings of all the students for having team presentations or possible visiting speakers. During weeks when there are no class meetings students are expected to use the time to work on their project.

Technological Proficiency and Hardware/Software Required

Students must be proficient in programming in the "C" language.

Required Readings and Supplementary Materials

There are no reading assignments but students can expect to spend time reading manufacturers information to determine if various components will work in their project.

There is no required text but we recommend the following:

- **Debugging: The 9 Indispensable Rules for Finding Even the Most Elusive Software and Hardware Problems** by David J. Agans (AMACOM, 2006, ISBN 978-0814474570).

Laboratory Facility

The projects will be constructed in the Advanced Technology Lab (OHE 240). Access to the lab is by USCard and students can work in the lab whenever they have time available including evenings and weekends. If necessary due to the size of the class, a reservation system will be used to allow team members to sign up to use the lab facilities at designated times.

The lab has a set of lockers available for the students to store their project and tools. Each team will be assigned a locker and issued a lock. Teams will receive a set of tools for use in the lab during the semester.

The EE 459Lx students are responsible for their activities in the lab. Do not invite friends to come and use the lab as a lounge or study room while you are there. All students should make an effort to keep the lab relatively neat and orderly. The tool you misplace today may be the one you will need next week. Notify the instructor if any lab equipment is not working or missing.

Interdisciplinary Product Development Teams

The teams of EE 459Lx students will collaborate with teams of design students from Otis College of Art and Design. The design students will work on the physical design of the product and its packaging. The engineering and design teams will work together throughout the semester to produce a final product that not only operates as specified from a technical standpoint but also incorporates the features that make it a well-designed and marketable product.

Teamwork and communication, both within the engineering teams and between the engineering and design teams, is an important part of the product development process. The full teams will be required to meet several times during the semester to discuss their project and resolve any problems that have come up.

Description and Assessment of Assignments

Lab Assignments

A small number of lab assignments will be given during the first half of the semester. They will all involve adding some hardware to the project board and demonstrating that it works as required. The purpose of the lab assignments is to get teams familiar with the equipment in the lab and working on aspects of their project that they will eventually need to have completed. The lab assignments do not require turning in a report on the work. Just showing the instructor what you have done is sufficient.

Project Proposal

Each team must prepare a written project proposal (3-5 pages) that describes what it is they are going to build. The proposal should describe the purpose of the product you plan to build, and give a brief description of how it will be used and how it will work. It does not have to go in to any detail about how it will be designed but should briefly discuss the major components you plan to include in it. It should include a block diagram of the project showing how the major components are interconnected. It should not include any detailed schematic diagrams or descriptions of the software or of the circuit on a gate level.

As part of your project your team will need to consider relevant engineering standards that apply to your product. This includes coding standards, component/interface standards, and design standards, but also extends to safety, ethical, and testing standards. Your proposal should discuss those that may pertain to parts of your project and you should plan on using those that are applicable.

An important part of the proposal is a time-line schedule showing when each project task is to be completed: designing, selecting components, simulating (if applicable), construction, debugging, etc. This timeline should include all the major tasks that the team will have to work on during the semester right through the writing of the final report.

The proposal will be graded based on how well it describes the proposed project and the writing style, grammar and form.

Office Meetings

During the semester all project teams are required to have several 30 minute meetings with the instructor to discuss their project and the progress they are making on it.

These meetings are normally held in the instructor's office but may be moved to a conference room or to the laboratory facility if needed. **All members of the team are expected to attend the meetings.** Have available all documents and notes about the project so you can show what has been accomplished and what still needs to be done. If possible, bring the project board so you can show what has been accomplished and how it will all fit together. Be prepared to discuss what you are currently working on and what you plan to do over the next few weeks.

These meetings are your chance to ask the instructor questions about various aspects of the project. If you are confused about something in the project or are concerned that you might have misinterpreted something in the project specification, bring this up at the meetings. You should not use these meetings as the primary time for the team members to get together and communicate. The team members should be in communication with each other throughout the week and the weekly meetings with the instructor is to bring him up-to-date on your project.

Office meetings are graded based on preparation and team interaction. It should be apparent to the instructor that the team members are communicating and working together.

Detailed Design Review

A detailed design review (DDR) is an oral slide presentation to the class of about 15 minutes. It is intended to go over all the necessary details of a project before it is implemented. Your DDR should provide an overview of the project that describes what it is you are building, and a detailed description of each hardware and software module in the project. This should be done at a block diagram level that shows the interface between each module. An experienced engineer, after seeing the DDR, should understand what you are building and not be left wondering how it is all going to work.

The DDR should include an estimate of the project's cost. Based on your design, estimate what components you think will be needed and come up with an estimate of the cost of constructing the project. Do not include any overhead, labor or manufacturing costs.

The detailed design review is graded based on how effectively it explained all the aspects of the project and how well the team member presented the information to the audience.

Project Design and Construction

The largest component of the course is the design and construction of the project. All team members are expected to contribute to the design and construction of the project in approximately equal amounts. Team members are responsible for making all decisions as to what tasks are assigned to each team member.

Teams are expected to work on their project on their own as much as possible. During many weeks there are no class meetings and teams should use this time to work on the project. The instructor will be available for advice and assistance throughout the week and students can request the instructor to come to the project lab to help them whenever issues arise.

Project teams are expected to set their own schedule for working on their project. During weeks when there are scheduled class meetings, each member of the team should plan to spend at least two additional hours working on the project. For weeks when there are no class meetings, each team members should plan to send about four hours on the project, which can include the 30 minute office meeting if scheduled that week. These hours typically grow substantially towards the end of the semester as the project due date approaches.

Project grading is subjective since each team's project is different and the instructor must judge how well their project meets the specifications set for their project as specified in their project proposal and whatever other features the team incorporated into the project.

Final Report

The project final report consists of an oral presentation to the class and a written report. The oral presentation is done from slides (e.g. PowerPoint) and should last about 20 minutes. The team should discuss all aspects of the project: what does it do, what it will it be used for, how does it work, what problems they encountered, how it complies with the various engineering standards that you discussed in your proposal, etc. It can include information on any interesting discoveries you made about the project and its components that you think people should know about. It should also include any conclusions you have reached about how the project could be improved upon if you had the time to implement these changes.

The written final report contains much of the same material as in the oral presentation but should go into more detail about the operation of the various components of the project. The report should include everything about the project: block diagrams, schematics, timing diagrams, pictures, etc. It should cover all aspects of the project in sufficient detail that any electrical engineer can read the report and understand exactly how it works. Length of the report should be around 15 pages but can vary depending on the number of topics that need to be discussed. It is not a journal of your semester ("...and then we added XYZ to the project ..."). The final report must contain a detailed cost analysis of the project. The idea here is to find out how much it would cost to produce a product based on your design, probably in large quantities. Examples of final project reports from previous semesters will be made available by the instructor.

Both parts of the final report, the oral presentation and the written report, are graded based on how well they explain all the important details of how the project works and how it was constructed. Besides the technical aspects, it will be graded for its effectiveness, form, writing style and grammar.

Grades

Final course grades are based on the formula below.

Proposal	=	8%	
Detailed design review	=	12%	
Project	=	40%	(a)
Final project oral report	=	10%	
Final project written report	=	15%	(b)
Weekly office meetings	=	8%	
Instructor's assessment	=	7%	(c)
Total		100%	

The projects in this course are team projects. Each individual is expected to contribute to the team effort, though it is often the case that some team members do more and some do less. In most cases every member of the team gets the same score for the proposal, design review, project and final report portion of the grade. However, if there is clear and convincing evidence that a team member contributed significantly less to these items than others, their score for that portion of the grade will be reduced.

Notes:

(a) Score is based on how well the project met the project specifications and whatever other features the team incorporated into the project.

(b) Besides the technical aspects, your final report will be graded for its effectiveness, form, writing style and grammar.

(c) The instructor's assessment will include teamwork, communication skills, work habits, methods used in accomplishing the project, and project scheduling.

Weekly Schedule

The schedule below is subject to change. Check the class web site for updates. The following terms are used:

"Class meeting" = All students meet in ?.
"Lab meeting" = All students meet in OHE 240.
"Office meetings" = Each team meets separately with the instructor for 20-30 minutes.

Week	Tuesday	Thursday
1 1/13 - 1/17	Class meeting - Overview of the course, project requirements	Class meeting - Everyone to introduce themselves. Discuss project topics
2 1/20 - 1/24	Class meeting - Teams meet with Otis teammates, product brainstorming	Class meeting - discuss project topics, product brainstorming
3 1/27 - 1/31	Class meeting - Teams meet with Otis teammates, product brainstorming	Lab meeting - Hardware construction techniques and lab tutorial, Lab 1 out
4 2/3 - 2/7	Class meeting - Teams meet with Otis teammates, product brainstorming	Lab meeting - Microcontroller programming, Lab 1 due, Lab 2 out
5 2/10 - 2/14	Office meetings Lab 2 due, Lab 3 out	
6 2/17 - 2/21	Office meetings Lab 3 due, Lab 4 out	Project proposals due
7 2/24 - 2/28	Office meetings Lab 4 due	
8 3/3 - 3/7	**Class meeting - DDR presentations**	**Class meeting - DDR presentations**
9 3/10 - 3/14	Office meetings	
 3/17 - 3/21	Spring Break	Spring Break
10 3/24 - 3/28	Office meetings	
11 3/31 - 4/4	Office meetings	
12 4/7 - 4/11	Office meetings	
13 4/14 - 4/18	**Class meeting - Ethics lecture**	
14 4/21 - 4/25	Combined Oral Presentations	Combined Oral Presentations Project demos due on Friday
15 4/28 - 5/2	Class meeting - Technical Presentations	Class meeting - Technical Presentations

- **The deadline for finishing the project is 4 P.M. on Friday, April 25th**. Teams must demonstrate their project, working or not, to the instructor by this time. The instructor will provide more information on the schedule for project demonstrations towards the end of the semester.
- The written final project report is due on the day of the scheduled final exam for the class. **Turn in the written final project reports to EEB 410 by 4 P.M. on Thursday, May 8th**.
- Return all items checked out (tools, lock, etc.) to EEB 410 by Wednesday, May 14th.

Policies

Intellectual Property

The nature of the projects in EE 459Lx makes it unlikely that any issues will come up related to the intellectual property rights of all or part of the project. However should such issues arise they will be resolved in a manner consistent with USC's policies on these matters.

Withdrawals

Last day to withdraw from the course **without** a mark of W is January 31, 2025. Last day to withdraw from the course **with** a mark of W is April 11, 2025. An incomplete grade can only be assigned if there is a verifiable cause that is acceptable to the instructor, the department and the University. Simply running out of time to complete the project is not grounds for being granted an incomplete.

Statement on Academic Conduct and Support Systems

Academic Conduct:

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, "Behavior Violating University Standards" (`https://policy.usc.edu/files/2020/07/SCampus-Part-B-2.pdf`). Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, (`http://policy.usc.edu/scientific-misconduct`).

Support Systems

Counseling and Mental Health - (213) 740-9355 – 24/7 on call
`https://studenthealth.usc.edu/counseling`
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call
`http://suicidepreventionlifeline.org`
Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-9355(WELL), press "0" after hours – 24/7 on call
`https://studenthealth.usc.edu/sexual-assault`
Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED) - (213) 740-5086 | **Title IX** – (213) 821-8298
`https://equity.usc.edu`, `http://titleix.usc.edu`
Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

Reporting Incidents of Bias or Harassment - (213) 740-5086 or (213) 821-8298
`https://usc-advocate.symplicity.com/care_report`
Avenue to report incidents of bias, hate crimes, and microaggressions to the Office of Equity and Diversity |Title IX for appropriate investigation, supportive measures, and response.

The Office of Disability Services and Programs - (213) 740-0776
`http://dsp.usc.edu`

Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

USC Campus Support and Intervention - (213) 821-4710
`https://campussupport.usc.edu`
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity at USC - (213) 740-2101
`https://diversity.usc.edu`
Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call
`http://dps.usc.edu`, `http://emergency.usc.edu`
Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call
`http://dps.usc.edu`
Non-emergency assistance or information.

Office of the Ombuds - (213) 821-9556 (UPC) / (323-442-0382 (HSC)
`https://ombuds.usc.edu`
A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.