USC Viterbi School of Engineering

Ming Hsieh Department of
Electrical and Computer Engineering

EE 109L - Introduction to Embedded Systems

Syllabus for EE 109L – Spring 2024

General Information

Lectures:	9:30-10:50 TTh (31019)	Redekopp	VHE 205
	11:00-12:20 TTh (31395)	Redekopp	GFS 101
	12:30-1:50 TTh (31291)	Weber	THH 116
	2:00-3:20 TTh (30999)	Puvvada	THH 114
Labs:	All labs sessions are held in VHE 205		
	12:30-1:50 W (30799)	11:00-12:20 F (31018)	
	2:00-3:20 W (31396)	12:30-1:50 F (30784)	
	3:30-4:50 W (31292)		
Quiz:	7:00-8:50 P.M. T (30530) - only used for quiz and midterm		

Instructors	**Email**	**Phone**	**Office**	**Office Hours**
Prof. Gandhi Puvvada	`gandhi@usc.edu`	310-733-8025	EEB 238	See the class web
Prof. Mark Redekopp	`redekopp@usc.edu`	213-740-6006	EEB 222	site for all faculty
Prof. Allan Weber	`weber@usc.edu`	213-740-4147	EEB 410	office hours.

Class web site: `https://bytes.usc.edu/ee109`

Overview and Objectives

This course introduces students to the fundamental concepts of computer systems and computer engineering **using embedded systems as a vehicle**. Concepts include information representations, embedded C language constructs, state machines, and fundamental circuit analysis. Specific embedded topics will include digital I/O, serial I/O protocols, analog-to-digital conversion and interrupt mechanisms. A lecture/lab course format will be employed to provide hands-on experience and active learning techniques. Upon completion of this course students will be able to:

1. Understand how digital systems represent information
2. Understand the execution model of a modern computer system
3. Design and implement combinational logic circuits
4. Design and implement sequential logic circuits and FSMs
5. Utilize a microcontroller to sense and activate digital signals
6. Utilize a microcontroller to perform analog-to-digital and digital-to-analog conversion
7. Use state machines as a system design tool
8. Write interrupt-driven and timer-driven programs
9. Design a non-trivial embedded project

Prerequisites and Corequisites

All students must either have taken or be concurrently taking a C/C++ programming course like EE 155, CSCI 103 or ITP 165, or be proficient in one of these programming languages before taking EE 109.

Course Material

Students will be provided with a project box of tools and electronic components that will be used throughout the semester for lab exercises. Students are expected to bring their project box to all the lab sessions. The project boxes and all tools and components must be returned at the end of the semester.

There is no required text but we recommend the following:

- **Digital Design with RTL Design, VHDL and Verilog, Second Edition** by Frank Vahid (Wiley, 2011, ISBN 978-0470531082).
- **Make: AVR Programming** by Elliot Williams (Maker Media Inc., 2014, ISBN 978-1449355784)
- **Debugging: The 9 Indispensable Rules for Finding Even the Most Elusive Software and Hardware Problems** by David J. Agans (AMACOM, 2006, ISBN 978-0814474570).

Format of Class

We will use a lecture/lab format to create a classroom environment where the instructor facilitates active student participation in their own learning process. Students are expected to set their own learning goals (i.e., be curious) and then actively pursue those goals both in and out of the classroom through personal study, programming, and in-class activities. Simply showing up to class is not enough; come to class ready to think, ask questions, and work with your fellow students. Small in-class and out-of-class activities (both individual and group-based) will be provided to help facilitate achievement of learning goals.

Recordings of Lectures

All students are expected to attend the lectures and labs in person. As per Viterbi School of Engineering guidelines there will be no online option for attending lectures or labs via Zoom. While Zoom attendance is not supported, lectures will be recorded for the sake of students who may need to isolate due to COVID or have other medical emergencies. Students who missed lecture due to such causes may request access to the recordings after the lecture. Access to the lecture recordings will not be granted simply because a student elected to skip the lecture to do something else. **Prior to the quiz, midterm and final exam** the lecture recordings that cover the material on those exams will be made available to allow students to review for the exam.

Collaboration Web Site

The class will be using the Piazza collaboration web site to facilitate communication between students and between students and the instructors. All students will receive an email shortly after the start of semester with a link for enrolling in the class Piazza page. Students are encouraged to use Piazza for class-related communication with the instructors. Posting to the Piazza site is preferred over email for discussion topics since you have the option of allowing other members of the class to join in the conversation.

Lab Assignments

The following is a brief description of how the EE109 labs assignments are conducted. A more detailed set of lab policies which are an extension of this syllabus will be handed out and discussed during the first lab meeting, or can be downloaded from the class web site's "Labs" page.

There will be approximately ten lab assignments. Lab assignments are larger, more comprehensive, assignments that should challenge you to integrate hardware and software concepts. Lab assignments will involve both designing and building circuits, and writing microcontroller software to interface with the hardware.

While most engineering labs are 2 hours, your registered lab is only 80 minutes. To maximize the value of in-person time and to make up the difference, we will ask you to watch a 15-25 minute introductory lab video each week **BEFORE** you come to your lab section.

Labs are discussed and assigned during the Wednesday and Friday lab sessions and are **due one week later**. Students who complete a specified portion of the assignment during the lab session in which it was assigned will receive one bonus point that adds to the lab score. The bonus points can offset grading deductions in other parts of this lab or in other labs.

The teaching assistants and course producers (CPs) will be available to help you during your assigned lab session and also hold office hours in VHE 205 throughout the week to help you with the assignment. A schedule of TA and CP hours is posted on the class web site and in the lab classroom.

Labs should be demonstrated and scored **before** coming to the lab session a week later. In the next week's lab session there will be an opportunity to demo the lab but **TAs and CPs will not be available to offer help**. No credit will be given for labs demonstrated after the end of the next week's lab session.

Material that must be turned in (write-ups and/or program source code) must be submitted online by 11:59 P.M. Friday of the week the assignment is due. Labs submitted late are subject to a -1 point deduction for one day late and -2 deduction for two days late. Labs submitted after 11:59 P.M. Sunday night will not be accepted. If an incorrect file(s) was submitted and found at the time of grading, it is a -4 deduction if a correct replacement file is provided promptly; no credit otherwise.

Any issues with lab grades and regrade requests must be submitted within **7 days** of the release of the lab's score, and should start with the grader listed on Vocareum who graded your lab. After 7 days, lab grades are final and will not be changed regardless of the reason for the discrepancy.

Lab assignments are to be completed individually. Students are expected to write their own software for all assignments. Labs are compared to current submissions by other students and previous student submissions. Copying (and then modification) of any portion of code from Internet sources or fellow students is prohibited unless cleared with the instructor.

After the semester: You **MAY NOT** post your solutions to lab assignments on public websites like github.com, etc. as they are derived from assignments which are copyrighted by your instructors and are the property of USC. Any such action will be deemed a violation of academic integrity!

Any academic integrity violation will result in submission to the Office of Academic Integrity (OAI) with a recommended sanction of F in the course. See the Statement on Academic Conduct (Page 4.)

Homeworks

There will be a few written homeworks throughout the semester. Assignments will be made available on the course web site and are due one week after it is made available unless indicated otherwise by the instructor. All homeworks will be submitted on Gradescope. Students will receive an email shortly after the start of the semester with link for enrolling in the class Gradescope page. Most homework assignments will use a combination of multiple choice or fill in the blank, while one or two will require scanning hand-drawn diagrams. All diagrams must be drawn neatly! Show how you solved the problem on all non-trivial problems. Homeworks may be turned in late for up to 2 days losing 20% of the max score per day (even if only a second late). After 2 days we will not accept late submissions. Solutions to the homework problems will be available on the class web site within a couple of days after the due date.

Exams

There will be a quiz, a midterm and final exam. The date of the quiz and midterm is shown on the attached schedule but may be moved to a different date. The quiz and midterm will be held during the Quiz section (Tuesday, 7:00 to 8:50 P.M.). The final exam will be held on the date and time specified by the University

for our class (**Saturday, May 4th, 2:00-4:00 P.M.**). Always check with the instructor as the listed exam date approaches to confirm the date and time. The exam dates will be announced in class and on the web site. You are responsible for finding out when and how the exams will be held. Makeup exams will be given if you have a valid excuse (e.g. serious illness or accident, urgent trip, but proof will be required). Your instructor may offer to transfer the missed exam's credit to the other two exams. **After exam scores have been released, you have one week to request a regrading** if you think the grading was in error. After the one week period is over, no further appeals can be made concerning the grading of the exam.

Project

During the last three or four weeks of the semester students will work on a project selected by the instructor. The project will incorporate several of the hardware and software concepts covered in the preceding weeks. Components for the project are not included in the tool kit handed out at the start of the semester but will be made available once the project has been discussed in the lab session. The deadline for having the project evaluated by the instructors is the end of your lab session during the last week of the semester. **All source code must be submitted by 11:59 P.M., Saturday, April 27th.**

Grades

The following point structure will be used in determining the grade for the course. Final grade will be based upon the total points received, the highest total in the class, and the average of the class.

Homeworks	7%
Labs	25%
Project	10%
Quiz	10%
Midterm	20%
Final	28%
Total	100%

After each homework, lab or exam is graded students have **one week** to request a change to the score. During that time if you feel your score is not correct you need to contact either the person who did the grading or your professor to request changes. After the one week period is over, the scores are frozen and not subject to further review or change.

Withdrawals

Last day to withdraw from the course **without** a mark of "W" on your transcript is February 23, 2024. Last day to withdraw from the course **with** a mark of "W" is April 5, 2024. An incomplete grade can only be assigned if there is a verifiable cause after the 12th week of the semester that prevented you from completing either the final exam or the class project and is acceptable to the instructor, the department and the University. Simply running out of time to complete the class assignments is not grounds for being granted an incomplete.

Statement on Academic Conduct and Support Systems

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 academic integrity in "The USC Student Handbook" on pages 11 through 13. Other forms of academic dishonesty as described in the Student Handbook are equally unacceptable.

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.

988 Suicide & Crisis Lifeline - 988 or 1 (800) 273-8255 – 24/7 on call
https://988lifeline.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, https://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.

Office of Student Accessibility Services (OSAS) - (213) 740-0776
(previously called Disability Services and Programs (DSP))
https://osas.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
https://dps.usc.edu, https://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
https://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.

Weekly Schedule

Week	Tuesday Lecture	Wednesday/Friday Lab	Thursday Lecture
1 1/8 - 1/12	Orientation, embedded systems, computer organization	Lab 0: Software installation, receive lab kit	Basic circuit analysis (voltage, current, Ohm's law)
2 1/15 - 1/19	Transistors, digital logic, combinational and sequential circuits	Lab 1: Exploration of KVL, KCL, Ohm's laws	Single variable Boolean algebra, combinational and sequential circuits
3 1/22 - 1/26	Number systems, binary, hexadecimal, character codes	Lab 2: Oscilloscopes, combinational gate network, delays	Microcontrollers 1 (bitwise operations)
4 1/29 - 2/2	Microcontrollers 2 (digital I/O), state machines	Lab 3: Digital I/O lab with Arduinos	Microcontrollers 3 (advanced bit fiddling), state machines
5 2/5 - 2/9	More state machines, LCDs and parallel interfaces	Lab 4: LCDs	Combinational logic design 1 (minterms/maxterms, Boolean algebra)
6 2/12 - 2/16	Combinational logic design 2 (more Boolean algebra, Karnaugh maps) **2/13: Quiz**	Lab 5: ADCs	Combinational logic design 3 (more Karnaugh maps)
7 2/19 - 2/23	Interrupts	Lab 6: Timers	Combinational logic design 4 (components: decoders and muxess)
8 2/26 - 3/1	Signed arithmetic	Lab 7: Rotary encoders	Adders
9 3/4 - 3/8	Sequential logic 1 (latches, FFs and registers)		
3/11 - 3/15	Spring Break	Spring Break	Spring Break
10 3/18 - 3/22	Sequential logic 2 (latches, FFs and registers)	Lab 8: Pulse width modulation	Hardware state machines 1
11 3/25 - 3/29	Hardware state machines 2 **3/26: Midterm**	Lab 9: Hardware datapath components	Hardware components (ALUs, registers, instruction cycle)
12 4/1 - 4/5	Processor organization (design of CPU)	Project	Processor organization (design of CPU)
13 4/8 - 4/12	Memory, FPGAs 1	Project	Memory, FPGAs 2
14 4/15 - 4/19	Performance (caching, pipelining)	Project	Interfacing (voltage and current capabilities)
15 4/22 - 4/26	Embedded failures	Project evaluations	Review