



EE250 Distributed System for the Internet of Things

Units: 4

Fall 2024, M/W 10-11:40 pm in ZHS 252

Location: GFS 106 and online at our website: <https://bytes.usc.edu/ee250>

Instructor: Mark Redekopp

Office: EEB-222

Office Hours: See course [webpage](#).

Contact Info: redekopp@usc.edu (Preferred communication via **Piazza) Office phone: 213-740-6006**

Teaching Assistant and UG Lab Assistants

Office, Office Hours, and Contact info: See website

IT Help: See Viterbi IT [website](#).

Course Description

This is a 4-unit undergraduate course aimed at electrical engineering, computer engineering and computer science students with at least a sophomore standing. Students will design, build and evaluate systems that incorporate hardware, operating systems, network and application layer protocols. Focus will be placed on distributed system applications for the Internet of Things. Through hands-on lab activities, assignments, projects, as well as through guest lectures spanning research and practice, the course provides a comprehensive introduction to many relevant topics including printed circuit board design, real-time operating systems, programming microprocessors, signal processing, wireless communications, networks, control systems, publish-subscribe middleware, cloud computing, databases, machine learning and security.

Weekly labs will provide the opportunity for students to apply networking and embedded programming concepts. Several written homeworks will also be given to help reinforce the concepts taught in lecture.

Learning Objectives

1. Develop applications that use the TCP/IP protocol suite and socket programming to make embedded devices communicate over the Internet.
2. Use publish-subscribe protocols such as MQTT to share messages in real time between distributed devices all over the Internet
3. Explain what real-time embedded operating systems do and the kind of programmer-support interfaces they provide
4. Analyze how low power wireless links behave in terms of metrics such as signal quality, error rates, throughput, as a function of link distance, channel and power settings.
5. Apply and describe various physical signaling schemes and codes used in the transmission of digital data.
6. Explain how randomized medium access (MAC) protocols such as CSMA, TDMA, etc. that allow multiple wireless devices to share a medium
7. Create circuit schematics and use those schematics to create a printed circuit-board (PCB) design and layout and test a PCB's functionality

8. Apply sleep cycling and asynchronous MAC protocols to prolong the battery lifetime of an embedded device
9. Process raw data / signals from sensors to minimize noise and to estimate useful parameters such as a device's location
10. Compare and contrast cryptographic encryption schemes and security protocols to protect the confidentiality and integrity of data.

Prerequisite(s): EE 109L and either EE 155L or CS 103L

Co-Requisite(s): None.

Concurrent Enrollment: None.

Recommended Preparation: None

Course Notes

All content will be provided on our website: <http://bytes.usc.edu/ee250>. PDF versions of lecture slides will be posted on our website before lecture and may be printed before coming to class or used electronically.

Technological Proficiency and Hardware/Software Required

A working laptop able to access the Internet is required to complete labs and some exams. Loaner laptops may be available via the [USC Computing Center Laptop Loaner Program](#). Other software and support is available from USC Technology Support and some useful links include: [Zoom information for students](#), [Brightspace help for students](#), [Software available to USC Campus](#).

Raspberry Pi

Students will be expected to have access to a Raspberry Pi embedded computer that contains the following:

- Raspberry Pi 3 (Regular or B+) or 4. Note: We abbreviate Raspberry Pi as "RPI")
- Micro USB Power Supply
- 16GB+ Mini SD Card

Fall 2024: Due to some lingering supply chain issues, RPi kits may have limited availability or cost issues. We have procured several that we can loan to you with a small deposit.

A kit containing a Raspberry Pi 3b may be purchased similar to this one [via Amazon](#) though you will need a 16GB or greater SD card. if you don't have a free one already.

GrovePi Sensor Kits

Finally, you will also use a sensor kit: [GrovePi Starter Kit from SeeedStudios](#). The sensor kits will be available and provided on loan, though some student enjoy purchasing one themselves for other projects and future use. If you'd like to do work remotely you will also need access to a wireless access point for which you can control the settings (home wifi access point or your cell phone).

Laptop

Students must also have a laptop capable of running Linux natively or via a virtual machine. A virtual machine will be made available on the course website.

Course Websites

1. **Primary website:** All course assignments, content, office hour information, etc. will be posted at our main website: <http://bytes.usc.edu/ee250>. This site will contain a link to a shared Google Drive folder where we will post all slides, labs, and homeworks. Please ensure you are able to access it.
2. **Q&A website:** A Q&A and announcement website will be utilized: <http://www.piazza.com/>. All official announcements regarding assignments, lectures, exams, etc. will be made via Piazza. It is your responsibility to check this site often.
3. **Shared Google Folder:** All slides, HWs, Labs, and other relevant documents will be posted in this folder. We will give access to your @usc.edu account.

4. **Vocareum:** Lab and project code submissions will be made via <http://www.vocareum.com>. You will receive an invitation link to create your account sometime in the second week.
5. **Blackboard:** Blackboard (<http://blackboard.usc.edu>) will ONLY be used to record grades and, in the event of an emergency, Zoom links will be posted there if class must be conducted online.

Attendance

In-person attendance is the only supported option for lecture and lab. For the sake of review and if you become ill, we will provide lecture recordings upon written request to a designated TA (see the course website homepage) as well as **1 week before exams**. We encourage you to review lecture notes, attend office hours, and form study groups in place of relying on recorded lectures for review.

Required Readings and Supplementary Materials

The following textbooks are **recommended** but not required. We recommend you read the sections listed on the course schedule below for the corresponding week **BEFORE** attending the first lecture of that week.

1. Practical Python Programming for the IoT, Gary Smart, Packt Publishing, 2020. Freely available via USC Libraries - will need to sign in to the libraries website to access the book (or choose "Institution not listed" when asked which institution you are part of, and then enter your usc.edu email when prompted. [Practical Python Programming](#)
Additional materials on Github:
<https://github.com/PacktPublishing/Practical-Python-Programming-for-IoT>
2. IoT and Edge Computing for Architects, 2nd Edition, Perry Lea, Packt Publishing, 2020. Freely available via USC Libraries (sign-in required) [IoT and Edge Computing](#)
3. Fundamentals of Wireless Sensor Networks, Theory and Practice. Dargie and Poellabauer. Wiley Publishing, 2010. ISBN 978-0-470-99765-9. **Freely available here:** [Fundamentals of Wireless Sensor Networks](#).
4. Distributed Systems, Third Edition by Tanenbaum and Van Steen, 2017. ISBN 978-90-815406-2-9). **Freely available here:** [Distributed Systems](#).
5. *Other online resources provided by the instructor.*

Description and Assessment of Assignments

Homeworks

Availability: Assignments will be made available on the course shared folder. These assignments are predominantly for your own practice and thus will be graded as CR/NC. **No penalty will be applied for missing 1 homework.** You are strongly encouraged to work on these individually and seek help from a course staff if you struggle to answer the question (as opposed to looking at the solutions or the work of another student).

Solutions: Solutions to the homework problems will be available on the course shared folder.

Labs

Overview: There will be at most 11 lab assignments. Lab assignments are the primary out-of-class work and should challenge you to learn NEW concepts somewhat beyond the scope of the class as well as integrate what is taught in class. **They are usually NOT simply step-by-step procedures** but involve problem solving and application of various concepts. As such you should be prepared to have to read and search out further information online as you perform the labs. Some labs may involve designing and building circuits, others may solely involve writing software.

Assessment: For each lab you will need to demonstrate certain portions of the functionality via in-person demonstrations and then code/writeup submission on Vocareum. Most of the credit will be given for the functionality that you demo to our course staff. The remaining portion of the credit will come from visual inspection of your code after you submit it. **All code should be neatly indented and have ample comments.** Failure to indent or include comments will lead to point deductions.

Before Attending Lab: It is expected that you will read the lab procedure COMPLETELY and watch any posted videos related to the lab **before you attend**.

Demonstration Due Date: Labs are assigned during the Tuesday lab sessions and **should be demonstrated in TA (not instructor) office hours before the beginning of next Tuesday's lab**. The teaching assistants hold office hours in the VHE 205 classroom. A schedule of TA hours is posted on the class web site. As a convenience if you did not demo during the week, we will allow **a single demo attempt for each student (team) in the first 10 minutes of the Tuesday lab**. Then, the next lab will be introduced **15 minutes from the start of the lab section**. So, if you already demoed earlier in the week, you need only be ready for lab by 15 minutes after the lab start time.

Submitting Your Code/Answers: Code and answers to lab questions (write-ups and/or program source code) must be submitted online (via Vocareum) **by midnight Thursday after the lab's demo deadline**.

Collaboration and Academic Integrity: Indicated lab assignments are to be completed either individually or in teams of two unless otherwise noted. **NO TEAMS OF 3 or MORE ARE ALLOWED**. When groups are used, pair-programming is expected (this means active participation of the student not physically at the keyboard). In addition, each person should have their own copy of the code so they can work in future weeks. During demonstrations, the TA may choose EITHER student to provide an explanation (rather than the team deciding who will provide an explanation) and will likely ask both students to provide input. **Copying (and then modification) or even LOOKING at or for any portion of code from Internet sources, fellow, or past students is prohibited** unless cleared with the instructor. We will be clear: **You are not to share or look at the code from another team**. See the Statement on Academic Conduct.

Late Submission: No credit will be given for demonstrations or code submissions after the due date(s). **It is your responsibility to submit on time. Don't procrastinate but submit early and often!** No excuses for WiFi connectivity, broken laptops, etc. will be allowed. This can easily be mitigated by pushing to Github regularly!

Lab Grading: Most labs will contain a point rubric at the end of the document. Ensure you have met those requirements before submission. Labs and the project will be graded on the Vocareum website (<http://www.vocareum.com>) with feedback and comments annotated inline with your code submission. The grade and feedback will be usually be posted within 1-2 weeks of submission.

Grading Disputes: We will work hard to post LAB scores and feedback within 1 week of the lab's due date. Any disputes with posted grades must be raised within 7 days of the score posting. Notice that any regrade request will result in us trying to give the fairest possible grade to you, which could be higher or lower than the one you received originally. Please see your TA to start the process and hopefully resolve the issue.

Project

Overview: During the last 2-3 weeks of the semester students will work on a more comprehensive project, in place of lab. The instructor may specify a particular project or students will be asked to propose their own project idea within certain guidelines and requirements.

Assessment: Projects will be evaluated not just on whether or not it works, but to a large extent on the quality of the hardware and software incorporated in it. One that operates well, is robust and reliable, and is user-friendly will receive more points than one that does not. A rubric will be posted along with the assignment. About half of the points will be based on the working demonstration. The other half will be based on the quality of the software code implementation as judged by visual inspection of particular rubric elements by our teaching staff as well as a short, written report/reflection.

Late Submission: No credit will be given for demonstrations or code submissions after the due date(s).

Exams

Time and Location: There will be one midterm. The date of the midterm is shown on the attached schedule but may be moved to a different date in exceptional cases. The exams may also be moved to a different classroom. 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 where the exams will be held. Makeup exams will be given only for a valid excuse (e.g. serious illness or accident acknowledge through Campus Support (support@usc.edu), urgent family issues, etc., but proof will be required).

Academic Accommodations: If you have USC approved academic accommodations, please check with your instructor 2 weeks before the exam to determine when and where you will take the exam.

Exam Style: Exams are designed to not only test your retention of the material but your ability to apply it to design and analyze new or novel problems. In this way, your mastery and depth of understanding of the course content will be assessed. Some portion of the exam will contain general knowledge questions and be fill-in/multiple choice, but other questions will come from design problems or apply the skills learned in class. This is where struggling with the homework and lab problems on your own and until you truly understand and feel comfortable with each concept will greatly pay off. *Students who simply "get the lab done" without reviewing and understanding each facet will often struggle on the exams.* While the instructor may alter the exam medium, it is likely we will use a combination of written (pen/paper) exams and **Gradescope**.

Grading Breakdown

[Including the above detailed assignments, how will students be graded overall? Participation should not exceed 15% of the total grade. Where it does, the syllabus must provide an added explanation. No portion of the grade may be awarded for class attendance, but non-attendance can be the basis for lowering the grade, when clearly stated on the syllabus. The sum of percentages must total 100%.]

Table 1 Grading Breakdown

Assignment	% of Grade
Homeworks	5%
	Note: Drop lowest HW
Labs	40%
Project	5%
Midterm	25%
Final	25%

Grading Scale

Course final grades will be determined using the following scale. If the grade distribution is lower than expected the scale may be shifted downward but will never be shifted upward.

A	94-100	B+	87-89	C+	77-79	D+	67-69	F	59 and below
A-	90-93	B	83-86	C	73-76	D	63-66		
		B-	80-82	C-	70-72	D-	60-62		

Assignment Rubrics

See the section above for relevant assessment procedures for homeworks.

Assignment Submission Policy

The course website will be updated to show due dates for all assignments. Assignments will generally be submitted via Vocareum, Gradescope, and/or Github. Instructions will be provided for each assignment.

Grading Timeline

Assignments will generally be graded within 1.5 weeks of submission. Any grading issues should be raised with the grader who graded the assignment and be cc'ed to the instructor as well.

Academic Integrity

The University of Southern California is foremost a learning community committed to fostering successful scholars and researchers dedicated to the pursuit of knowledge and the transmission of ideas. Academic misconduct is in contrast to the university's mission to educate students through a broad array of first-rank academic, professional, and extracurricular programs and includes any act of dishonesty in the submission of academic work (either in draft or final form).

This course will follow the expectations for academic integrity as stated in the [USC Student Handbook](#). All students are expected to submit assignments that are original work and prepared specifically for the course/section in this academic term. You may not submit work written by others or "recycle" work prepared for other courses without obtaining written permission from the instructor(s). Students suspected of engaging in academic misconduct will be reported to the Office of Academic Integrity.

Other violations of academic misconduct include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

You are NEVER allowed to show, verbally describe, or otherwise share any part of your code with another student who is not part of your group (or to anyone if the assignment is to be done individually). You should NOT verbally describe your code or guide another student on what to write or what to do. Furthermore, coding together on labs should be done with caution. Developing similar pseudocode or even planning together when done at a detailed level can lead to code that is pretty much the same (and really a team effort vs. an individual effort) and is considered a violation. Finally, copying (and then modification) or just "viewing for reference" any portion of code from Internet sources (including AI or fellow students) is prohibited unless explicitly cleared with the instructor.

Academic dishonesty has a far-reaching impact and is considered a serious offense against the university. Violations will result in a grade penalty, such as a failing grade on the assignment or in the course, and disciplinary action from the university itself, such as suspension or even expulsion.

For more information about academic integrity see the [student handbook](#) or the [Office of Academic Integrity's website](#), and university policies on [Research and Scholarship Misconduct](#).

Please ask your instructor if you are unsure what constitutes unauthorized assistance on an exam or assignment or what information requires citation and/or attribution.

Policy for AI-generated work.

Since creating, analytical, and critical thinking skills are part of the learning outcomes of this course, all assignments should be prepared by the student working individually or in groups. Students may not have another person or entity complete any substantive portion of the assignment. Developing strong competencies in these areas will prepare you for a competitive workplace. **Therefore, using AI-generated work in whole or in part (even for reference) is prohibited in this course, will be identified as plagiarism, and will be reported to the Office of Academic Integrity.** Use of AI-generated work applies to extensions and other add-ins to apps (for example, many code editors now have AI-assistive technology extensions that can generate code as you write it). These are the same as going directly to ChatGPT or similar tool. **Note: Students with a pending violation or who are found to have violated academic integrity may NOT drop the course.** The penalty for violations is a 0 on the assignment and a letter graded deduction (i.e. B to C, etc.).

You MAY use generative AI tools for working on **non-graded practice**, or conceptual questions that don't involve HW-specific problems. Use it to help you practice on OTHER problems so that you can do the HW on your own and with the help of only the course staff.

Course Content Distribution and Synchronous Session Recordings Policies

USC has policies that prohibit recording and distribution of any synchronous and asynchronous course content outside of the learning environment.

Recording a university class without the express permission of the instructor and announcement to the class, or unless conducted pursuant to an Office of Student Accessibility Services (OSAS) accommodation. Recording can inhibit free discussion in the future, and thus infringe on the academic freedom of other students as well as the instructor. ([Living our Unifying Values: The USC Student Handbook](#), page 13).

Distribution or use of notes, recordings, exams, or other intellectual property, based on university classes or lectures without the express permission of the instructor for purposes other than individual or group study. This includes but is not limited to providing materials for distribution by services publishing course materials. This restriction on unauthorized use also applies to all information, which had been distributed to students or in any way had been displayed for use in relation to the class, whether obtained in class, via email, on the internet, or via any other media. Distributing course material without the instructor's permission will be presumed to be an intentional act to facilitate or enable academic dishonesty and is strictly prohibited. ([Living our Unifying Values: The USC Student Handbook](#), page 13).

Course Evaluations

Official USC Course Evaluation will be conducted at the end of the semester. However, intermediate feedback regarding course staff may be solicited after the midterm.

Course Schedule

IMPORTANT: In addition to in-class contact hours, all courses must also meet a minimum standard for out-of-class time, which accounts for time students spend on homework, readings, writing and other academic activities. USC standards nominally expect 2 hours of outside work per week for each unit.

	Topics/Daily Activities	Readings and Homework	Lab to be Introduced
Week 1	Overview of IoT, Networks, and Embedded OSs; <i>Python and Git Video Intro (Video Lecture)</i>	FWSN: Ch. 1-2 (Overview, Examples) IoT&EC: Ch. 1 Practical Python Programming	Lab 1 – Raspberry Pi (Individual)
Week 2	Holiday: Labor Day (9/2) (OSI) Layered Model of Networks	IoT&EC: Ch. 10	Lab 2 – GrovePi (Individual)
Week 3	Transport Layer (TCP/UDP) Application Layer - HTTP	DS: 193-203 (Sockets)	Lab 3 – TCP/UDP
Week 4	Pub/Sub Middleware (MQTT) MAC Layer (802.11, 802.15)	FWSN: Ch. 5 IoT&EC: Ch. 5-7	Lab 4 – Web Services & REST APIs
Week 5	More MAC + PHY Layer	FWSN: Ch. 5 IoT&EC: Ch. 5-7	Lab 5 – MQTT
Week 6	PHY Layer	FWSN: Ch. 6 IoT&EC: Ch. 4	Lab 6 – ADC and PCB Design
Week 7	PHY ADC	FWSN: Ch 3.1 IoT&EC: Ch. 3	Midterm Review in Lab Optional Lab: Wireless Measurement
Week 8	More ADC Midterm: Wed. Oct. 16th in class	Class Notes	<Open Lab – Lab 6 work and midterm review>
Week 9	ML Signal Processing and Filtering	DS: 501-529 (Security) FWSN: Ch. 11 IoT&EC: Ch. 13	Lab 7 – Machine Learning
Week 10	Cloud & Distributed Computing	Class notes IoT&EC: Ch. 12	Lab 8 – Signal Processing and Distributed Computing
Week 11	Security	Class Notes IoT&EC: Ch. 8,11	Lab 9 – Instrumentation
Week 12	Energy Efficiency and Sleep Scheduling	FWSN: Ch. 8, 9 DS: 76-101 (System Arch)	Lab 10 – PCB Soldering Project Intro
Week 13	Embedded Operating Systems Real-time OS and Threads	FWSN: Ch. 3.2, Ch. 4 DS: 104-116 (Threading) IoT&EC: Ch. 8	Project Work
Week 14	Synchronization & IPC	Class Notes	Project
Week 15	More Threading/Synchronization Review	Class Notes	Project Demo
FINAL	Final on Mon. Dec. 16th at 8 a.m.		Date: For the date and time of the final for this class, consult the USC <i>Schedule of Classes</i> at classes.usc.edu .

Statement on University Academic and Support Systems

Students and Disability Accommodations:

USC welcomes students with disabilities into all of the University's educational programs. [The Office of Student Accessibility Services](#) (OSAS) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at osas.usc.edu. You may contact OSAS at (213) 740-0776 or via email at osasfrontdesk@usc.edu.

Student Financial Aid and Satisfactory Academic Progress:

To be eligible for certain kinds of financial aid, students are required to maintain Satisfactory Academic Progress (SAP) toward their degree objectives. Visit the [Financial Aid Office webpage](#) for [undergraduate-](#) and [graduate-level](#) SAP eligibility requirements and the appeals process.

Support Systems:

[Counseling and Mental Health](#) - (213) 740-9355 – 24/7 on call

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

[988 Suicide and Crisis Lifeline](#) - 988 for both calls and text messages – 24/7 on call

The 988 Suicide and Crisis Lifeline (formerly known as the National Suicide Prevention Lifeline) provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week, across the United States. The Lifeline consists of a national network of over 200 local crisis centers, combining custom local care and resources with national standards and best practices. The new, shorter phone number makes it easier for people to remember and access mental health crisis services (though the previous 1 (800) 273-8255 number will continue to function indefinitely) and represents a continued commitment to those in crisis.

[Relationship and Sexual Violence Prevention Services \(RSVP\)](#) - (213) 740-9355(WELL) – 24/7 on call

Free and confidential therapy services, workshops, and training for situations related to gender- and power-based harm (including sexual assault, intimate partner violence, and stalking).

[Office for Equity, Equal Opportunity, and Title IX \(EEO-TIX\)](#) - (213) 740-5086

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) 740-2500

Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures, and response.

[The Office of Student Accessibility Services \(OSAS\)](#) - (213) 740-0776

OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

[USC Campus Support and Intervention](#) - (213) 740-0411

Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

[Diversity, Equity and Inclusion](#) - (213) 740-2101

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

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) 442-1200 – 24/7 on call

Non-emergency assistance or information.

[Office of the Ombuds](#) - (213) 821-9556 (UPC) / (323-442-0382 (HSC)

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.

[Occupational Therapy Faculty Practice](#) - (323) 442-2850 or otfp@med.usc.edu

Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.