CE346/CS346: Microcontroller System Design

Syllabus - Spring 2025

Course Staff

Instructor

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Overview

The Internet of Things promises a world of computers woven into our physical world. These computers do not look and function the same as the servers and desktops that have long dominated the computing world. Instead, they take the form of microcontrollers with a processor, memory, and peripherals all within a single chip. Microcontrollers are then embedded into circuit boards alongside sensors, batteries, and interfaces that connect it to the outside world.

In this course, we explore the design and use of these microcontroller-based systems. What are the requirements and capabilities of embedded software? How do we connect computation to real-world input and use it to output to actuators or other nearby computer systems? How can sensors be used and combined to understand a computer's physical environment? Along the way we'll discuss many aspects of software and electrical system designs and how they can be made to work together. The class will include lectures on these topics, practical hands-on lab sessions interacting with microcontroller systems, and an open-ended final project.

Location and Time

Lecture time: 3:30-4:50 PM Central, Tuesdays and Thursdays
Location: Tech LR5

Lectures are in person. We will attempt to record all lecture sessions so that you can later review them if you want, but the current expectation is that students will attend class in person.

Lab time: Fridays, 1:00-2:50 PM Central or 3:00-4:50 PM Central
Location: Frances Searle Building, Room 2370

Labs are in person and attendance is mandatory. If you will not be able to attend a lab session, you must reach out to the instructor to let them know as soon as possible.

Pre-requisites

CS211 and either CS205 or CS213, or graduate standing.

This course also expects students to have a background in C programming and Unix shell. While we will deal with aspects of electrical engineering, computer engineering, and computer science, the course does not expect students to have experience in all of these areas and will teach what we expect you to know.

Communication

All course materials will be posted to Canvas including grades, lecture materials, and class recordings. Piazza will be used for course discussions and questions. **All questions should go to Piazza rather than to email.** We will enroll you in Piazza. Office hours will also be available, with the regular schedule available on Canvas. Office hour appointments can also be made with the instructor by Piazza post to “Individual Student(s) / Instructor(s) → Instructors”.

Class Structure

Schedule

The course schedule is available on the Canvas homepage for the course. Be aware that it is subject to change, although warnings will be given to students for any major changes.

Labs

These provide guided, hands-on experience with microcontroller systems. Labs will be started on Fridays during the lab session, but will likely not be completed during the session. Labs will be performed with a partner and will be due the following week before the next lab starts.

1. Memory-Mapped I/O and Interrupts
2. Timers
3. LED Matrix
4. Breadboarding
5. Audio
6. I2C Accelerometer/Magnetometer

Each lab will require a demonstration that the lab has been completed, usually in the form of multiple checkoffs throughout the lab procedure. Attendance for labs is required and part of your lab grade. If you must miss a lab for an excused reason (either academic or sickness related), let the instructor know as soon as possible, preferably in advance.

Quizzes

These will evaluate your understanding of course material. Quizzes will be given roughly every two weeks, with a total of four quizzes throughout the class. Students will be given a limited amount of time to complete several questions from the last two weeks of lecture.

Final Project

These are open-ended and are a chance for you to show off your creativity. They will be performed in groups of 2-3 students (four is possible with approval, alone is not allowed). The labs should help give you some basis of knowledge for a project, but a large variety of projects are possible. Feel free to look around online for inspiration.

Various items on hand may be lent out to teams for use in their projects. Teams will also have a small budget for purchasing supplies for their project based on the number of team members.

Example ideas:

- Interactive game
- Musical instrument
- Electronic clothing
- Smartwatch
- Robotics

Project proposals will be due about 1/3rd of the way into class. They will include a short writeup of the project plan and the instructor will provide feedback about them.

Halfway through the class, students will give Project Design Presentations in class. These will be short presentations to the class on project goals, steps, and concerns and should take into account feedback from the proposal. Other students in the class, as well as the instructor, will be able to provide feedback on how to shape your project.

Updates meetings may occur once or twice between Design Presentation and submission, detailing completed work, unexpected challenges, and revisions to the project goals.

Finally, a demonstration will be given for each project. The demo will be a few hours where the team will show off the relevant aspects of their project. These will take place during exam week if possible. Project demos will be open to the public.

The final projects themselves are also graded based on quality and difficulty. The proposal, presentation, and updates will be used to guide students so that they can anticipate how their project will be judged. The project code must also be submitted and will be graded based on quality.

Class Hardware

Throughout the quarter, you will borrow various hardware from the class (Microbit and project supplies). All hardware borrowed MUST be returned before the end of the quarter. Anyone who does not return hardware before the end of the quarter will receive an Incomplete grade in the course until hardware is returned.

Grades

Percentage grades will be converted to letter grades using the standard letter grade system (93% A, 90% A-, 87% B+, etc.). However, these grade bins may be moved at the instructor's discretion for the advantage of students. Note that the percent grade displayed by Canvas is not always accurate and may not take late penalties into account, as described below.

Each category of assignment has a total value, which is divided evenly between assignments.

Category	Count	Total Value
Lab Checkoffs	6	42%
Quizzes	4	20%
Project Proposal	1	4%
Project Design Presentation	1	4%
Project Demonstration	1	5%
Project Quality & Difficulty	1	20%
Project Code	1	3%
Project Partnership Survey	1	2%

Late Policy

Quizzes may not be submitted late. Final project items may be submitted late only with prior approval from the instructor. Labs may be submitted late at a penalty of 10% reduction in maximum points per day late. For example, a lab submitted two days late has a maximum score of 80%. Lateness is rounded up to the whole day, so an assignment that is five minutes late has the same penalty as an assignment 23 hours late.

If you are having an issue preventing you from completing some part of the class on time, please contact the instructor as soon as possible and we will work together on a solution. Particularly for issues outside of the student's control, such as major injury, sickness, or family emergency, deadlines can be shifted without penalty if you contact the instructor.

Academic Integrity

Your work must be your own. For group work, it is expected that all group members will have equally and substantially contributed to the work.

Collaboration is a really good thing, and we encourage it. On the other hand, cheating is a very serious offense, which carries serious consequences. It is OK to meet with colleagues, form study groups, discuss assignments with them, compare alternative approaches, go over examples from textbooks or other sources. **But it is never ok to share lab code or homework solutions, or even to see each other's lab code or solutions.**

What you turn in must be your own work. Copying (or even studying) code, solution sets, etc., from anywhere (e.g., other people, web, GitHub, AI) is strictly prohibited. It is acceptable to discuss possible issues and solutions verbally with each other, without viewing code.

For the **final project**, the requirements are more lax, since you are each working on unique projects. You *may* share final project code with each other **as long as the source is properly documented**. You may also obtain final project code from sources on the internet or from generative AI, again as long as it is properly cited. In all cases, it must be fully clear which code is your own, independent creation and which code has been sourced from others. You will be graded on both your project as-a-whole, but also on your own unique contributions.

It is the responsibility of every student in this class to be familiar with and to adhere to the Academic Integrity Policies of Northwestern University and the McCormick School of Engineering. Any suspicion of violation of these policies will be reported immediately to the Associate Dean for Undergraduate Studies. If you are in doubt whether your actions constitute a violation of the above policies, ask the instructor (before doing what you are unsure about).

Sickness and Common Sense

Generally, if you are sick do not attend class. Instead contact your instructor as soon as possible and we'll figure out a way to handle the situation. I expect all students to use their discretion and make good choices for the community.

Accessibility

I believe in providing reasonable accommodations that allow for full access to learning for all. Please contact me for anything that might have an impact on your participation in this course (documented disability, language challenges, absences for religious observations, etc.).

Class Recordings

This class or portions of this class will be recorded by the instructor for educational purpose and available to the class during the quarter. Your instructor will communicate how you can access the recordings. Portions of the course that contain images, questions or commentary/discussion by students will be edited out of any recordings that are saved beyond the current term.

Diversity and Inclusion

I consider this classroom to be a place where you will be treated with respect, and I welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, ability—and other visible and nonvisible differences. All members of this class are expected to contribute to a respectful, welcoming, and inclusive environment for every other member of the class.

Northwestern is committed to fostering an academic community respectful and welcoming of persons from all backgrounds. To that end, the policy on academic accommodations for religious holidays stipulates that students will not be penalized for class absences to observe religious holidays. If you will observe a religious holiday during a class meeting, scheduled exam, or assignment deadline, please let me know as soon as possible, preferably within the first two weeks of class. If exams or assignment deadlines on the syllabus fall on religious holidays you observe, please reach out so that we can discuss that coursework.

This course will also include a mix of undergraduates and graduate students with differing backgrounds in embedded systems, computer science, and electrical engineering. Do not feel discouraged by this. Each student will bring a different aspect of their knowledge to discussions, and we'll all be contributing towards increasing each other's understanding.

Northwestern University Syllabus Standards

This course follows the Northwestern University Syllabus Standards. Students are responsible for familiarizing themselves with this information.