Microprocessor System Design
CE346

Syllabus - Spring 2021

Course Staff
Branden Ghena (Instructor)
branden@northwestern.edu

Abu Bakar (TA)
abubakar2023@u.northwestern.edu

Julian Richey (PM)
julianrichey2021@u.northwestern.edu

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 computing. 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
Lectures: 10:00-10:50 AM Central, Monday/Wednesday/Friday
All lectures will be held in zoom and recorded.

The strength of this class will be in discussion, however, so plan on attending every lecture and being willing to speak up, even over zoom. Mondays and Wednesdays will be primarily "lecture", with course content and discussion. Fridays will be primarily "lab" and "project" focused, with small, guided projects and time for discussion and meetings about final projects.

Prerequisites
CS211 and either CS205 or CS213. The course also expects students to have a background in C programming and shell commands. 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.

Course Materials
There is no course textbook. We'll be interacting with plenty of specifications and datasheets, and possibly a few research papers. But they will all be freely available online.

Each student will have a lab kit including a microcontroller dev kit, a breadboard, and various components. This kit will be sufficient for all labs and for the final project, although students may choose to include additional components in their final project depending on their goals.

Class Resources
All course materials will be posted to Canvas including grades, Zoom URLs, and class recordings. Campuswire will be used for course discussions and questions. **All questions should go to Campuswire rather than to email.** We will enroll you in Campuswire. Office hours will also be available, with the regular schedule available on Canvas. Office hour appointments can also be made with the instructor or TA by Campuswire post.

Grades
- 45% - Labs (6 labs at 7% each, 1 getting started lab at 3%)
- 30% - Quizzes (4 quizzes at 7.5% each)
- 25% - Final Project

This formula (both weights and components) is subject to change. The mapping from numeric grades to letter grades will be at instructor discretion, but this class is not graded on a curve.

Labs
These provide guided, hands-on experience with microcontroller systems. Labs are done individually, will be started on Fridays in class, and will have about a week to be completed. These are subject to change in case there are problems getting them working.

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

Each lab will require a demonstration that the lab has been completed as well as several post-lab questions demonstrating your knowledge.

Quizzes
These will evaluate your understanding of course material. Quizzes will be given every two weeks through canvas. Students will be given a limited amount of time to complete several questions from the last two weeks of lecture. Students will have multiple days over which to take the quiz.

Final Project
These are open-ended and are a chance for you to show off your creativity. They can be performed individually, or preferably in groups. 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.

Example ideas:

- Video game with motion controls
- Music pad controller
- Morse code decoder
- Smartwatch
- Tamagotchi

Project proposals will be due about 2/3rd of the way into class. They will include a short writeup of the project plan and a discussion with the instructor about the project.

Updates will be given once or twice between proposal and submission, detailing completed work, unexpected challenges, and revisions to the project goals.

An in-class demonstration will be given for each project. The demo will be 5-10 minutes where the team will show off the relevant aspects of their project. These will take place the last week of class.

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

Late Policy
For each calendar day after the due date for a lab, quiz, or project portion, 10% is lost from the maximum score. For example, after 2 days the maximum score is 80%.

Accessibility
Any student requesting accommodations related to a disability or other condition is required to register with ANU (accessiblenu@northwestern.edu; 847-467-5530) and provide professors with an accommodation notification from AccessibleNU, preferably within the first two weeks of class. All information will remain confidential.

Should you need them, additional campus resources are available, including, but not limited to:

- Accessible NU www.northwestern.edu/accessiblenu/
- CAPS www.northwestern.edu/counseling/index.html
- Student Enrichment Services www.northwestern.edu/enrichment/

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

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.

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 of microcontroller systems and the Internet of Things.

Recording
Portions of this class will be recorded by the instructor for educational purposes. These recordings will be shared only with students enrolled in the course and will be deleted at the end of the quarter. Recordings will be available on Canvas under the "Panopto" tab.

Schedule (tentative)
This course is being modified for Spring 2021, so this schedule is definitely subject to change.

Week	Date		Lecture		Labs (release date)	Other Assignments
	March 30	Tuesday	1	Introduction		
	March 31	Wednesday	2	Microcontrollers		
1	April 2	Friday	3	Embedded Programming	Getting Started (on your own)	
	April 5	Monday	4	Hardware I/O		
	April 7	Wednesday	5	Digital I/O and Circuits		
2	April 9	Friday		Lab Session	MMIO and Interrupts	Quiz 1 out
	April 12	Monday	6	Timers		
	April 14	Wednesday	7	Driver Design		Quiz 1 in
3	April 16	Friday		Lab Session	Timers	
	April 19	Monday	8	*Catch-up / Potpourri*		
	April 21	Wednesday	9	System Prototyping		
4	April 23	Friday		Lab Session	LED matrix	Quiz 2 out
	April 26	Monday	10	Analog Input		
	April 28	Wednesday	11	Sensors		Quiz 2 in
5	April 30	Friday		Lab Session	Breadboarding	
	May 3	Monday	12	Analog Output		Project Proposals
	May 5	Wednesday	13	Wired Communication UART		
6	May 7	Friday		Lab Session	Audio	Quiz 3 out
	May 10	Monday	14	Wired Communication SPI, I2C		
	May 12	Wednesday	15	Wired Communication USB		Quiz 3 in
7	May 14	Friday		Lab Session	I2C Accelerometer	
	May 17	Monday	16	Wireless Communication		
	May 19	Wednesday	17	Nonvolatile Memory		
8	May 21	Friday		Project Meetings		Quiz 4 out
	May 24	Monday	18	Managing Energy		
	May 26	Wednesday	19	*Catch-up / Potpourri*		Quiz 4 in
9	May 28	Friday		Project Meetings		
	May 31	Monday		No Class - Memorial Day		
	June 2	Wednesday		Project Demonstrations		
10	June 4	Friday		Project Demonstrations		