University of California, Berkeley
Department of Mechanical Engineering

ME 100: Electronics for the Internet of Things

Fall 2021 Course information

Overview

Welcome to ME100, Fall 2021! This class provides you with a broad introduction to electronics, including basic circuit principles, design of simple digital systems, use of microcontrollers, information transmission, and instrumentation. We also introduce some principles and applications of the "Internet of Things" (IoT)—which means connecting sensors and actuators to physical objects to track and control their status remotely, and thereby enable new functions. IoT is of rapidly growing importance in mechanical engineering for many reasons—including the prevalence of sensing and internet connectivity in (autonomous) vehicles, increasing factory automation, and the large efficiency gains possible with predictive maintenance of machinery (i.e., using data from measurements to fix machines before they break).

You will learn this material through a sequence of guided take-home labs and an open-ended final project in which you will conceptualize and prototype an Internet of Things application. Learning is also supported through weekly homework and two midterm assignments.

To make it easy to follow the course content during remote learning, the course is organized into modules. If you click on 'Modules' on the left-hand side of the bCourses page, you will see all the lectures, lab, and homework assignments, etc, arranged in a logical order. If you work through these items sequentially while observing the deadlines given, you will be able to stay on track and do well in the class. The modules are:

1. Course introduction and ESP32 microcontroller familiarization,
2. Circuit principles and components,
3. Communications technologies,
4. Electronic devices and logic,
5. Sensors,
6. Actuators and drives,
7. Real-world IoT applications, and
8. Semiconductor manufacturing.

Below is further detailed information about how the course is organized and run.

Course staff

Name	E-mail	Office hours
Dr George Anwar Course instructor	ganwar@berkeley.edu	M and W, 3:00 PM – 4:00 PM
Stefanie Senjaya GSI	stefaniebelinda@berkeley.edu	TBD
Jason Ho GSI	jjasonho7@berkeley.edu	TBD
Massimiliano De Sa GSI	mz.desa@berkeley.edu	TBD

Lectures

MWF 9:00 AM – 9:59 AM 105 Northgate Hall

Discussions

These will be held on Zoom, starting the week of January 26, and you can join whichever section you prefer; you do not need to attend the same section every week. These will be recorded and posted to bCourses. Attendance is not required but is highly encouraged.

- Section 101: Tu 11- 11:59 AM
- Section 102: F 11 – 11:59 AM
- Section 103 Tu 11-11:59 AM

All discussion sessions will start the week of August 30th.

Labs

Content

There will be seven structured labs, covering the following topics:

1. Familiarization with the ESP32 microcontroller board
2. Solar cell characterization; current and voltage sensing and logging
3. Linear circuits and learning to use the oscilloscope
4. MQTT: a lightweight protocol for transmitting data to and from IoT devices
5. Signal rectification
6. Pulse-width modulation; analog to digital conversion and vice versa
7. Using inertial sensors

A detailed guide will be provided for each lab, usually during the weekend before you are scheduled to begin the lab. For planning your work location, you will need a WiFi connection for most of the labs, which can be your home WiFi, or a phone hotspot.

All labs will start the week of August 30th

Working individually or in pairs

You may work individually or in pairs on the labs (no teams of more than two though). If you work in a pair, please make sure you follow applicable physical distancing requirements (e.g. working in different locations and using instant messaging). You can change whether you work individually or in a pair from lab to lab, and you may work in a different pair each week if you like. We recommend using the ME 100 Piazza site to find a lab partner if you would like to find one.

Lab kits

You will have received information about receiving your lab kit, the cost of which is partially covered by your ME 100 course materials fee (the remainder of the cost is covered by a donation that has been made to the Department). This kit has been redesigned to aid remote learning, and also to serve the needs of ME102B and ME103. Please therefore

keep the kit safe so that you can use it if/when you take those classes in future semesters. While occasional accidentally broken components will be replaced free of charge within reason, the Department will not furnish a whole new kit for those later classes. Similarly, if you drop ME 100 this semester, please keep the kit safe, ready for the semester when you do complete this course requirement.

Resource hub: microkit.berkeley.edu

To accompany the physical lab kit, we have launched a companion website, https://microkit.berkeley.edu/, that includes some getting-started guides for various microcontroller applications. This site supplements and does *not* replace the lab-specific handouts that you will be using. You can create an account on the Microkit site and add comments if you think they will be helpful to other students. The site is open to the world to view. Our hope is that over time the number of pages will grow to cover many different applications relevant to Mechanical Engineering projects. Please send us your suggestions!

Lab sections/timing/assistance

There are six remote lab sections, scheduled at the following times:

- Lab 201: Tu 8–11 AM
- Lab 202: Tu 2–5 PM
- Lab 203: W 2–5 PM
- Lab 204: Th 8–11 AM
- Lab 205 Th 2-5 PM
- Lab 206 F 2-5 PM

You are of course free to complete the labs at any time you like before the signoff deadline (though they will be much more enjoyable if you start early and do them gradually!). You can avail yourself of any of these section times, regardless of the section you are officially signed up for as long as space is available and Covid-19 safety protocols are upheld.

Signoff

There will be an online Gradescope “assignment” for each lab. The primary means of checkoff will be to upload a video to show your lab working as asked for in the lab handout (e.g. LED flashing; logged data appearing on your computer screen, etc). We will also usually ask you to upload your code, and there may be a couple of other fields for you to complete to show your understanding. If anything is unclear to us from your uploads, we will contact you with any clarification questions we have. Each lab is worth 5 points and we expect that everyone will be able to get 5/5 with reasonable effort. We want you to enjoy the labs and not be anxious about getting every last part of the lab to work perfectly, but we also want you to persevere within reason. So as long as we can see you have made significant effort and progress, a score of 5/5 is possible.

If you choose to work in a pair, you will only need to do one upload per pair per lab and will list the contributions of each person in Gradescope. We will give the same score to both people in the pair.

Homework

There will be seven homework, done on Gradescope, and generally due on Friday nights. We will post the homework at least one week before they are due and aim to provide graded HW within two weeks of the deadline.

Midterm assignments

There will be two midterms, on Gradescope. Each will be live for 48 hours:

- Midterm 1: launched Tuesday October 5, 8am; deadline **Thursday October 7, 8am.**
- Midterm 2: launched Tuesday November 16, 8am; deadline **Thursday November 18, 8am.**

Each midterm will be designed to take about two hours, but you will not be required to complete them in a single sitting, and you will not be limited to two hours. You can update your solutions at any point up until the deadline by clicking the "Resubmit" button in Gradescope, editing your answers, and saving them.

Project

The class will include a design project in which you will conceptualize, design, and implement a prototype of an IoT application. The brief is deliberately open-ended, but we will give you some ideas via examples in the class and discussion of current IoT trends. The project may be done individually or in pairs. There will be three deliverables, for which more detailed guidance will follow later:

- **Concept outline** – a few slides explaining the need identified, target users, requirements, and proposed approach to solving the problem.
- **Design review** – live oral presentation of progress during lab sections, with Q&A from instructors and classmates, followed by uploading progress slides.
- **Final outcome** – demonstration of the project outcome by uploading a video of the project outcome and slides explaining the design process.

Obtaining additional components

The lab kits contain a fairly wide range of components, including sensors, a motor, and a rotary encoder. We are trying to establish a protocol for you to receive additional components from the Hesse labs if you establish a need for them during your project. You may also use other components that you already have or can obtain, although we encourage simple and elegant solutions, and in principle you could score 100% on the project using only the components in the kit.

Custom hardware

While the clear focus of the project is the electronics and the software to control them, we know that some projects may involve custom mechanical components, casings, brackets etc to demonstrate function. If you have a means to make such components, you are welcome to do so. You may also wish to take advantage of "Makerfleet", the 3D printer farm that Jacobs Institute is making available for prototyping this semester. As a non-Jacobs-affiliated course, ME100 students are limited to the Ultimaker printers; you send in your design, pay only for materials, and pick up the printed components or get them shipped to you: https://jacobsinstitute.berkeley.edu/makerspace-access-shelter-in-place/

Credit weighting

Credit for the class is apportioned as follows:

- Homework (7 assignments, equally weighted): 15%
- Lab signoffs (7 labs, equally weighted): 20%
- Two midterms, equally weighted: 40%
- Project: 25%
    - Concept and plan: 25% of project score
    - Design review presentation and slides: 25% of project score
    - Final outcome: 50% of project score

There is no final exam.

Reference texts

There is no required text, and all notes will be provided in the form of lab handouts, lecture notes, and supplementary materials. If interested, here are some books that I can recommend:

The Art of Electronics by Horowitz and Hill (Cambridge University Press) is a classic: TK7815 .H67 2015 in the

Engineering Library. It is far more detailed than needed for this class, but is very practically oriented, and written in an entertaining conversational style. http://oskicat.berkeley.edu/record=b20247324~S1

Getting Started in Electronics by Forrest Mims (Lincolnwood) is concise and very accessible: TK7825 .M56 2003 in the Physics Library. http://oskicat.berkeley.edu/record=b23958581~S1

Academic integrity

We will be adhering to the Berkeley Honor Code (http://asuc.org/honorcode/index.php). If anyone has any questions about the responsibilities they have as part of this Code, or concerns about possible breaches of it, please contact Prof. Taylor.

Late assignments

We do ask that you try to complete assignments by the deadlines. We will be accommodating of occasional slightly late assignment completion but may penalize frequent or egregious lateness. Please make sure you communicate with your GSI or Professor Anwar if for any reason you think you need more time for an assignment.

Revision history

Date	Revision
01/18/2021	Document Created
08/25/2021	Updated for Fall