University of California, Berkeley
Department of Mechanical Engineering

ME 100: Electronics for the Internet of Things

Spring 2021
Course information

Overview

Welcome to ME100, Spring 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
Kevin Widjaja GSI	kevinwidjaja10@berkeley.edu	TBD

Schedule

Below is a summary of the semester's activities. You can also track upcoming assignments using the "Syllabus" link on the left-hand side of the bCourses page. Although lectures will be pre-recorded for asynchronous viewing, I have nominally associated each lecture with a particular day to help you pace your viewing.

Week commencing	M Lecture	W Lecture	F Lecture	Lab (checkoff due online two Mondays after the start of the lab week shown*, 11:59pm)	Other assignments (due F of week shown*, 11:59pm)
Jan 18		L1 Overview	L2 Python programming	No lab: collect/receive kit	–
Jan 25	L3 Quantities, circuits, and symbols	L4 Resistive circuits; Kirchoff's laws	L5 Resistive circuits continued	Lab 1 – ESP32 Familiarization	HW0 – Self-introduction
Feb 01	L6 Equivalent circuits	L7 RLC circuits; complex impedance	L8 Frequency response	Lab 2 – Solar cell characterization; current and voltage sensing	HW1 – Resistive circuits; Python practice
Feb 08	L9 Diodes	L10 Transistors	L11 Transmission protocols: MQTT	Lab 3 – Linear circuits; Wheatstone bridge; load cell	HW2 – Equivalent circuits; RLC circuits; phasors
Feb 15	President's Day	L12 Transmission protocols: coding	L13 Radio transmission	Lab 4 – MQTT	HW3 – Phasors, frequency response, diodes, and transistors
Feb 22	L14 Introduction to digital electronics; combinatorial logic	L15 Combinatorial logic continued	L16 Combinatorial logic; sequential logic; project intro	Lab 5 – Rectification and radio	HW4 – Coding; transmission; radio
Mar 01	L17 Sequential logic	L18 Sequential logic	L19 Microprocessor structures	Project concept generation	Midterm 1 (Modules 1–3)
Mar 08	L20 Microprocessor structures	L21 Operational amplifiers	L22 Op. amps continued	Lab 6 – Analog/digital conversion and pulse-width modulation	HW5 – Combinatorial and sequential logic
Mar 15	L23 Analog/digital conversion (ADC)	L24 Analog/digital conversion continued	L25 General-purpose input/output (GPIO)	Project development time	HW6 – Op. amps
Mar 22	Spring Recess	Spring Recess	Spring Recess	Spring Recess	Spring Recess
Mar 29	L26 IC Design	L27 Ways of powering IoT devices	L28 Ways of powering IoT devices	Project design reviews	HW7 – ADCs
Apr 05	L29 Sensing principles	L30 Mechanical sensors	L31 Location and proximity	Lab 7 – Using accelerometer and gyroscope	HW8 – Sensors (mechanical)
Apr 12	L32 Location and proximity	L33 Motor technology	L34 Motor drivers and encoders	Project development time	Midterm 2 (Modules 4–6)
Apr 19	L35 IoT case studies	L36 IoT case studies	L37 Alternatives to Micropython	Project development time	HW9 – Sensors (other)
Apr 26	L38 Semiconductor manufacturing: processes	L39 Semiconductor manufacturing: processes	L40 Semiconductor manufacturing: design and intellectual property	Project demos	HW10 – Motors and drives
May 03	RRR	RRR	RRR	Project demos	

* Unless otherwise notified.

Project deadlines:

- Mar 05: Project concept and plan
- Apr 16: Upload final version of presentation from design reviews in the previous week
- May 15: Upload materials documenting final project outcome

Lectures

Recorded material

All lectures will be recorded and posted on bCourses. You can access them by going to “Modules” in bCourses, and then clicking on the page associated with the specific lecture that you want to view. The recorded lectures will be posted within 24 hours after the lecture.

Lecture sessions will use this Zoom link:

https://berkeley.zoom.us/j/98973084901?pwd=MkI3eEdYU2laeFZBRktoR0FzNjBKZz09
Passcode: **673385**

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: Monday or Wednesday 4–5 PM

Both discussion sessions will use this Zoom link:

https://berkeley.zoom.us/j/98973084901?pwd=MkI3eEdYU2laeFZBRktoR0FzNjBKZz09
Passcode: **673385**

Labs

Content

There will be eight 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 and radio
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, but unfortunately not “enterprise” networks needing authentication, like AirBears2. If you run into difficulties finding a suitable WiFi connection, please let us know and we will help you find a solution.

Remote working

For the time being at least, all labs will be remote since the campus administration has decided to start the semester this way. If things later open up and if we are able to make Hesse access available, we will let you know. Meanwhile, please work in a suitable physically-distanced location, such as at home!

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!

Oscilloscopes

In addition to the kit, we are loaning you a mini oscilloscope for the duration of ME 100. The significant costs of these 'scopes have *not* been covered from the course materials fees, but from a one-off donation that was made to the Department. Therefore, we will need you to return the 'scopes to us when you finish or drop ME 100, so that future ME 100 students will be able to enjoy the same resources as you. If we "lose" scopes, we will not be able to afford to replace them in future years. We will work with you at the end of the semester to organize returns in a mutually convenient way and will accommodate people who are away from Berkeley and may need to return them at the start of the Spring semester.

Lab sections/timing/assistance

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

- Lab 201: M 5–8 PM (Dr Anwar)
- Lab 202: Tu 2–5 PM (Kevin)
- Lab 203: W 5–8 PM (Dr Anwar)
- Lab 204: Th 2–5 PM (Kevin)

Since labs are remote, you are of course free to do 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!) However, Kevin and Dr Anwar have committed to be online during the scheduled times above to answer questions as they come up. You can avail yourself of any of these section times, regardless of the section you are officially signed up for. Virtual queuing for help will be handled via the following website: https://me100.not.cs61a.org/ If you have not used OkPy before, you will first be prompted to create an account. Then you enter the topic you need help with, and staff will be in touch when you reach the front of the queue. They will coordinate a means of communication directly with you (e.g. Zoom, instant message, etc). At other times, you are welcome to see if an instructor is logged into https://me100.not.cs61a.org/, or use Piazza to crowdsource advice, or e-mail the instructors.

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 ten 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 March 2, 8am; deadline **Thursday March 4, 8am.**
- Midterm 2: launched Tuesday April 13, 8am; deadline **Thursday April 15, 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 in the week of March 29, 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 (10 assignments, equally weighted): 15%
- Lab signoffs (8 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 Eitan if for any reason you think you need more time for an assignment.

Revision history

Date	Revision
01/18/2021	Document Created