E40M

An Introduction to Making: What is EE?

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What is Electrical Engineering?

• Electrical Engineering is built on a foundation of science and math.
• Physics used to be the primary science but today biology and even some chemistry are becoming important.
• EEs are primarily problem driven “system integrators”. Hardware and software, experiment and theory, modeling and simulation are used to devise solutions to important problems.
• EEs are responsible for many of the products we all take for granted.
Outline of Course

This course introduces many of the foundational ideas of EE, but does so in a hands-on, hopefully fun and interesting way.

EE concepts are introduced in the context of 4 lab projects:

• Solar USB charger

• Useless box

• LED cube

• EKG
Solar USB Charger (1 week)

- Concepts:
  - Voltage
  - Current
  - Power
  - KCL, KVL
  - Energy conservation

- Devices
  - Diodes
  - Voltage source/battery
  - Resistors
  - Soldering iron
  - DMM

A solar panel charges a battery which provides power to charge a cell phone. But the cell phone requires 5V to charge and the battery only provides 3.7V, so we’ll also need a voltage converter circuit.
Useless Box (2 weeks)

- **Concepts**
  - Finite State Machines
  - Digital Logic
  - Binary numbers
  - CMOS Gates
  - Programming

- **Devices**
  - Motors
  - Switches
  - nMOS
  - pMOS

In this lab you’ll assemble a “useless box” like the one featured in Make Magazine & on YouTube. When the switch on the box is flipped “on”, a finger comes out of the box and turns the switch “off”.
LED Cube (3 weeks)

- Concepts
  - Coding
  - Light
  - Sound
  - Transforms/equalizers

- Devices
  - LEDs
  - Audio jacks
  - Analog to digital converters

An LED cube is a 3D shape made entirely of light emitting diodes. The LED cube is wired to a computer (Arduino) which controls individual LEDs to display interesting patterns.
ECG (1 week)

• Concepts
  – Amplifiers
  – Impedance
  – Noise
  – Safety
  – Filters

• Components
  – Capacitors
  – Inductors
  – Instrumentation and Operational Amplifiers

In this project we will build an electrocardiogram (ECG or EKG). This is a noninvasive device that measures the electrical activity of the heart using electrodes placed on the skin.
Class Logistics - Workload

- We think that you will get out of a class what you put into it
  - And we want you to get a lot out of this class

- So if you are looking for an easy class to satisfy GER
  - Take another class!

- But in return for your time you will learn valuable skills
  - For both work and play
  - And you will build toys you get to keep

- And we will try to make the class fun!
  - So (we hope) the time you spend on it just flies by
  - If it is not fun, please let us know!
Class Requirements

• Attend lecture and do the prelabs!
  – We will work on some of the prelabs/homework in class
  – Generally M/W lectures will cover EE basics needed for the lab projects. Friday lectures will be specific skills/information associated with following week’s lab.

• Do the lab project each week
  – You will sign up for a 3 hour lab slot
  – Work in 2 person teams – partners will change w/ projects

• Homework each week reviews key concepts
  – Not meant to be time intensive, checking you get key points

• There will be a midterm and final
Grading

• 50% - Lab assignments
  – 25% Function
  – 25% Style
    • How clean is your physical design?
      – Did you follow good lab techniques
      – Clean construction will also make your designs easier to debug
    • How easy is it for us to understand your code?
      – Or, how easy will it be for you to understand your code in 3 months

• 40% - Exams
  – Midterm, Final – equally weighted

• 10% - Homework
Lecture Logistics

• Class is scheduled MWF 3 pm – 4:20 pm in 420-040.

• Class will generally be about 1 hour with extra time for in-class “office hours”.

• Mon/Wed lectures will cover EE basics needed to understand and do the labs. HW and exams will be based on this material.

• Fri lectures will be “Prelabs” designed to cover material needed to do the lab project the following week.
Lab Logistics

• Class will be divided into groups of 8 - 10 people
  – Each group will have a “master maker,” a.k.a. CA, SL
  – That person will help you throughout the quarter
  – Projects will be done in teams of 2 people
  – You will partner with ½ the people in your group

• Lab is located in Packard 130, 131
  – It is the first floor near Bytes Café
  – You will have an assigned time
  – But you can come to the lab at other times to finish up projects, if there’s a free bench. Monday will have no scheduled lab sections, but the lab will be open for much of the day.
Class Website

- We will post all class materials, announcements, HW, grades etc. on the class website. [http://web.stanford.edu/class/engr40m/](http://web.stanford.edu/class/engr40m/)
- Lectures will be recorded and posted on Box after class [https://stanford.box.com/s/3ry4kewsut73ip32p2ekjwp7kj3be80y](https://stanford.box.com/s/3ry4kewsut73ip32p2ekjwp7kj3be80y). In class “office hours” will generally not be recorded.

- We will not bring hardcopies of class materials to class. Please print or download these before class.

- We will use Piazza [https://piazza.com/class/j0o7rvp9g8d4gs](https://piazza.com/class/j0o7rvp9g8d4gs) for questions. Please post all questions about class concepts, HW clarifications etc. so the TAs and instructors can provide answers that everyone can benefit from.

- For personal questions, please email TAs or instructors directly.
The Textbook

• There is a class reader for this class, and most of the lecture topics are discussed there, on the class website.

• In addition there is a reference text: A. Agarwal and J. Lang, *Foundations of Analog and Digital Electronic Circuits*, Morgan and Kaufmann, 2005.

• The textbook is generally more mathematically rigorous than the lectures, the homework, the labs, or the exams, and is available on-line.

• Coding in general and Arduino coding in particular are not covered in the textbook, but will be covered in the labs and Friday lectures.
• Debugging is hard
  – By definition things are not working they way they should
    • Or at least the way you think they should
  – You need to find the error
    • Could be in your understanding of the problem
    • Could be what you built is not what you think you built
    • Could be that the part/board is broken

• Don’t let it get to you
  – It is frustrating for everyone
  – Ask for help, fresh eyes are great
    • That is what the Master Makers are for
Rough Outline of the Class

• Weeks 1 - 2
  – Voltage, current, power; Batteries, DMM
  – Introduction to “EE Making”: Learning to solder
• Week 3
  – How to reason about circuits
  – Lab 1: Building a solar charger
• Week 4
  – Breadboards, MOS transistors, digital logic
  – Lab 2a: Building a useless box; switches, motors
• Week 5
  – Learning how simple computers work; coding; light and sound
  – Lab 2b: Building a computerized useless box; Intro to Arduino
Outline (cont’d)

• Week 6
  – Capacitors; Midterm
  – Lab 3a: Building an LED display
• Week 7
  – A new way to think about circuits: impedance
  – Lab 3b: Controlling your LED display
• Week 8
  – Electronic filters; Op-amps
  – Lab 3c: Tricking out your LED display
• Week 9
  – Instrumentation Amps, bio signals and safety; inductors
  – Lab 4: Measuring your ECG
• Week 10: review and final exam (June 9, 3:30-6:30)