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.

Nintendo SONY HITACHI
Panasonic DELL
SAMSUNG amazon
TOSHIBA Microsoft
Google NOKIA
LG intel

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 — BASIC CIRCUITS
- Useless box — DIGITAL
- LED cube — DIGITAL
- EKG : ECG — "INTERFACE" → ARDUINO.

Solar USB Charger (1 week)

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

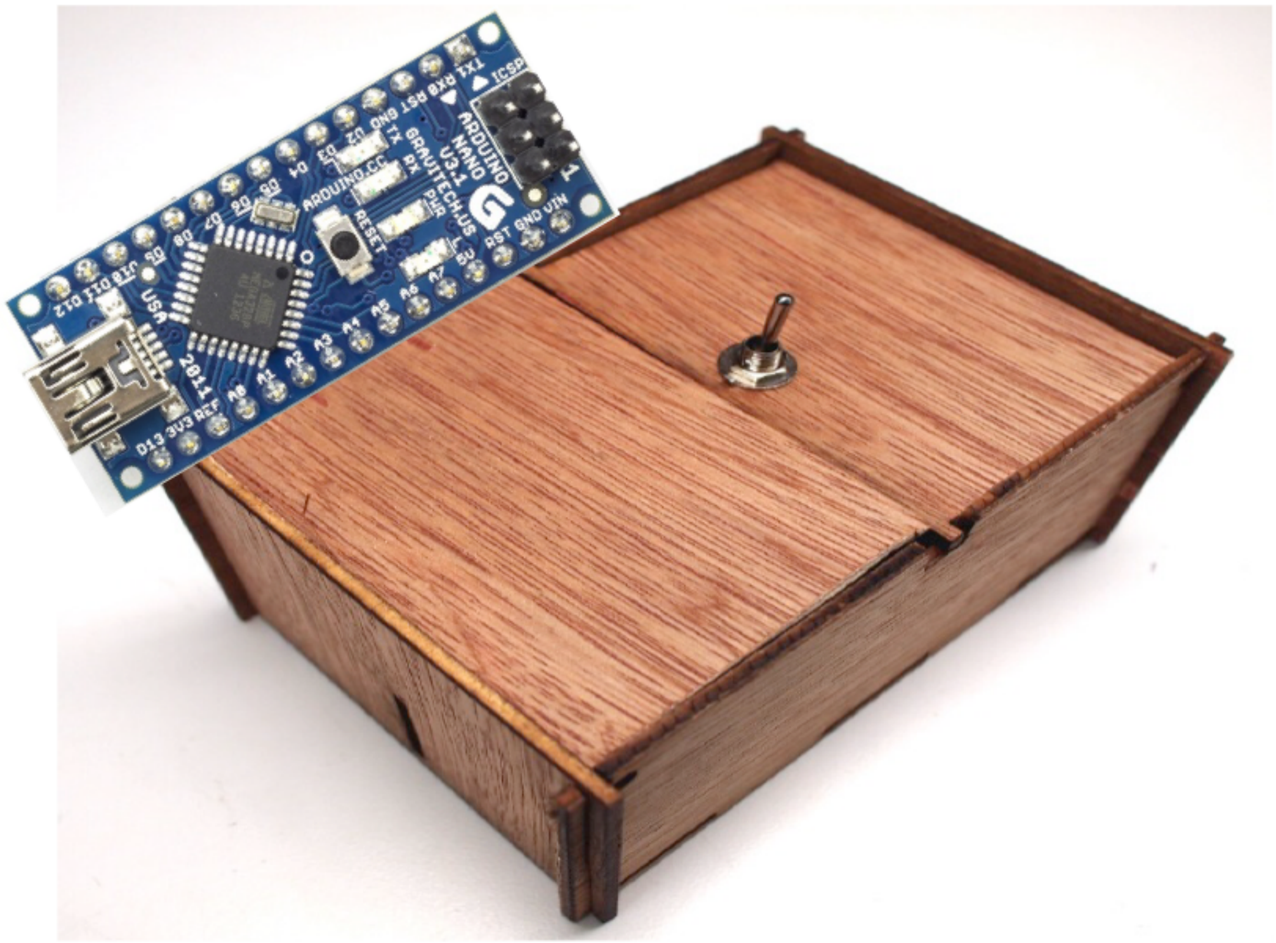
- Devices
  - Diodes
  - Voltage source/battery
  - Resistors
  - Soldering iron
  - DMM

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

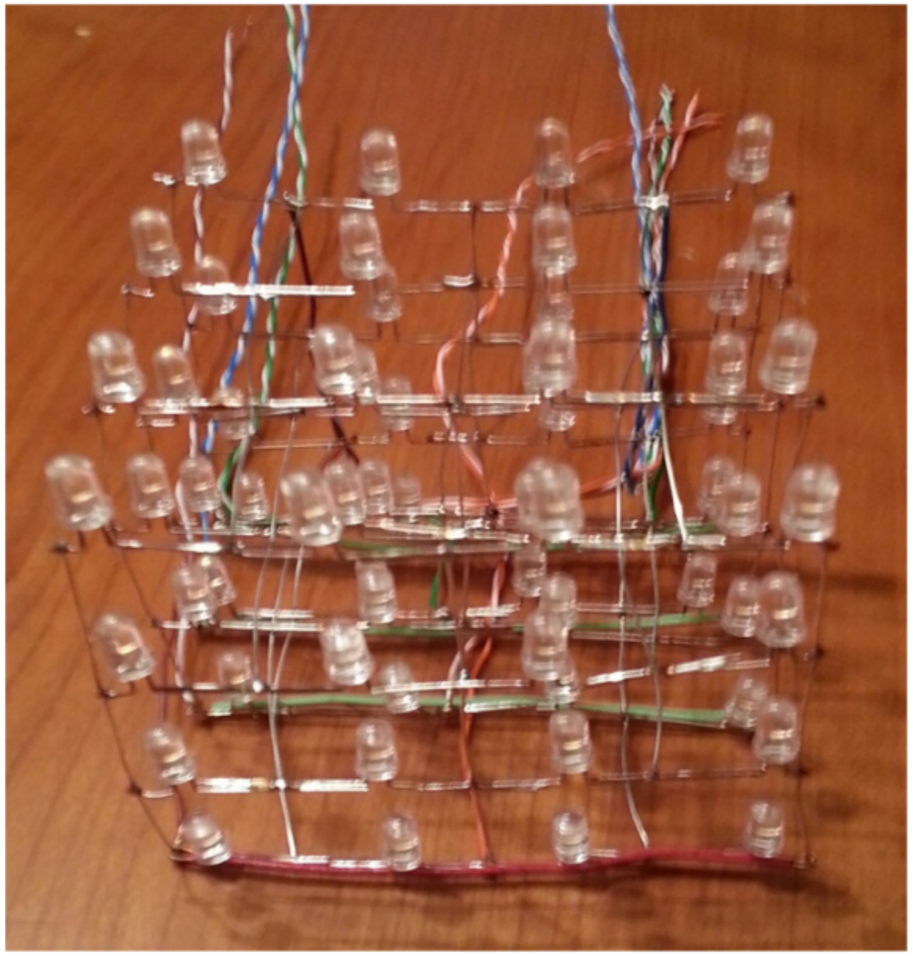


In this lab you'll assemble a "useless box" like the one featured in Make Magazine & on YouTube. When the switch on the box is flipped "on", a finger comes out of the box and turns the switch "off".

LED Cube (3 weeks)

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

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

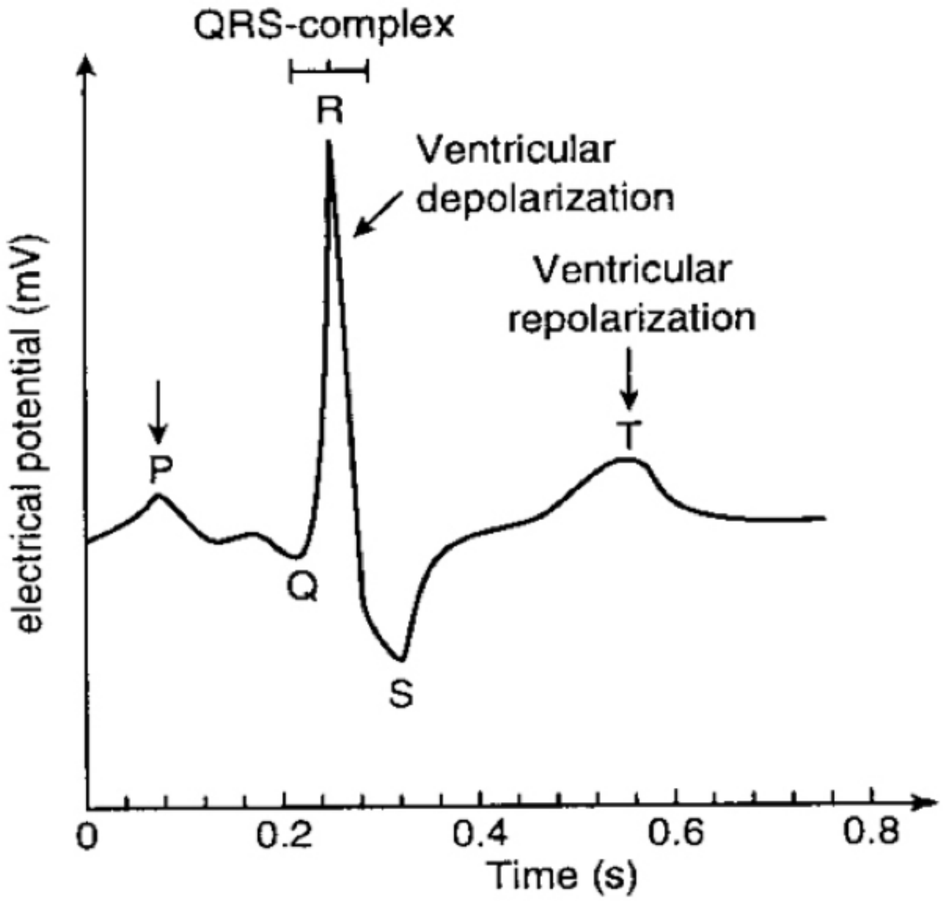


An LED cube is a 3D shape made entirely of light emitting diodes. The LED cube is wired to a computer (Arduino) which controls individual LEDs to display interesting patterns.

ECG (1 week)

- Concepts
  - Amplifiers
  - Impedance
  - Noise
  - Safety
  - Filters

- Components
  - Capacitors
  - Inductors
  - Instrumentation and Operational Amplifiers



In this project we will build an electrocardiagram (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

MAY 10 JUNE 9 (EVENING)

- 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/
- Lectures will be recorded and posted on Box after class 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 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.

Important!

- 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

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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)