Technological MacGyverying with the Arduino Microprocessor

Syllabus Final Version, Dec. 21, 2021

Overview

This course will utilize the Arduino Starter Kit and the Arduino Internet of Things Kit. By keeping on pace to do virtually every project in these two kits, we will have the last few weeks of the course to do special projects, for example to solve campus problems, like opening vents or taps. Heck, maybe someone will try to re-program the baler!

I am going to quote at length from the project book that goes with the starter kit:

> Everyone, every day, uses technology. Most of us leave the programming to engineers because we think coding and electronics are complicated and difficult; actually, they can be fun and exciting activities. Thanks to Arduino, designers, artists, hobbyists and students of all ages are learning to create things that light up, move, and respond to people, animals, plants, and the rest of the world.
>
> Over the years Arduino has been used as the "brain" in thousands of projects, one more creative than the last. A worldwide community of makers has gathered around this open-source platform, moving from personal computing to personal fabrication, and contributing to a new world of participation, cooperation and sharing.

We will be working with real circuitry (not just software to be downloaded onto the microprocessor). Therefore I will be teaching you some of the basics of electricity (voltage, current, power) and circuit elements (resistors, capacitors, diodes). The brains at the center of each circuit is the Arduino microprocessor which has to be programmed to do whatever you want it to do. The programs are developed in the Arduino IDE (Integrated Development Environment), which is downloadable onto most any computer.

When we get to the Internet of Things, I will be introducing key technologies (HTTP, HTML, CSS, and JSON) in just enough detail that the underlying mechanisms are understandable (rather than magic) and that the students can extend the projects in the kits in new directions.

Class Activities

- You Demonstrating (circuitry built between classes, either as homework, or later on your special projects)
- Professor Explaining Theory of Circuits
- Professor Demonstrating Practical Circuit-Building and Coding
- You Building Projects

Pace

I originally anticipated that the students would complete one to two Arduino projects per week for 10 or so of our 14 weeks together. In fact, we were able to do a project in almost every class. Thanks to the enthusiasm and actual pace we were able to complete almost every project in the two kits.

Lab fee for kit (includes textbook) and computer requirements

This course will have a lab fee for the Arduino kits which are $85 each. The kits include a compact and well-regarded projects book which will serve as our textbook. Many colleges would attempt to save money by having students work in pairs. There are of course advantages to working in pairs, but they are overwhelmed by the disadvantage that in most cases one person ends up doing much more of the hands-on work. After we have exhausted the capability of the kits, we will plan special projects and buy additional parts as needed for them.

You will need to download the Arduino IDE onto a laptop.

Grading

* Your homework will principally be completing projects

* One exam near the beginning of Term 3 testing knowledge of circuits and knowledge of Arduino programming

* Special project and presentation at the end of Term 3

Course credits

Four Deep Springs credits (standard semester-length course)

Technological MacGyvering Daily Schedule Term 2

Course home page

See also Daily Schedule Term 3

Week 1 — Beginning Circuitry — Basic Theory

- Tuesday, Aug. 30 — Unpack Arduino kit — Fire up Arduino IDE v. 1.8.15 — Project 0: First program (blinking light) and first circuit (powering an LED) — Practcical: breadboards, power supplies, circuit diagram schematics (symbol for battery, symbol for resistor, symbol for diode, symbol for switch) — Theory: Mechanical Energy and Power (including definitions of the Joule and the Watt) — More practical: Resistor Color Codes
- Friday, Sept. 3 — Homework for Friday: Finish Project 1 (which illustrates series and parallel switches) — Theory: Charge, Current, and Potential (including why circuits are always closed loops, and definitions of the Coulomb, the Ampere, and the Volt) — Start Project 2 (Spaceship Interface)

Week 2 — Coding — Sensors

- Tuesday, Sept. 7 — Homework for Monday: Finish Project 2 (which is your first program that combines the programmability of the Arduino with a circuit) — Theory: Resistors and Batteries (including IV Curves, the Ohm, Pull-Down Resistors) — Start Project 3 (discuss for loops and "if/else if/else" statements)
- Sept. 10 — Homework for Friday: Finish Project 3 — Theory: Summary of Electrical Concepts and Units Introduced so Far, Current at Junctions, Resistors in Series, Resistors in Series and Parallel — Homework for Tuesday, Problem Set 1.

Week 3 — Diodes and Transistors

- Tuesday, Sept. 14 — Problem Set 1 Solution — Silicon-based Semiconductors, Holes and Electrons, np junctions, diode IV-curve
- Friday, Sept. 17 — npn Junctions and the Photo-Transistor — Complete Project 4 — Pulse Width Modulation

Week 4 — RC Circuits

- Tuesday, Sept. 21 — RC Circuit Theory starting with a Primer on Exponentials — Complete Project 5 (Servo Controlled by Potentiometer Mood Meter)
- Friday, Sept. 24 — Finish RC Circuit Theory — Discuss Analogy with Spring/Dashpot Systems — Complete Project 6 (Theramin) — Frequency Modulation and Amplitude Modulation — Homework for Tuesday: Problem Set 2 on Capacitors, RC Circuits, and Diodes

Week 5 — Diving Into the C Language

- Tuesday, Sept. 28 — Read Chapter 3 of Programming Arduino by Simon Monk — In-Class: Start the Sieve of Eratosthenes Programming Assignment — Problem Set 2 Solution
- Friday, Oct. 1 — Read Chapter 4 of Programming Arduino by Simon Monk — Complete Sieve of Eratosthenes — Programming Assignments for Tuesday — Easier Option: Factorials and Fibonacci — Harder Option: Rail-Fence Cipher — Reference on Binary, Octal, and Hex representations: [Conversions Between Number Bases[(https://condor.depaul.edu/psisul/conversionmath.html)

Week 6 — Applying C Language to Embellish Projects

- Tuesday, Oct. 5 — Read Chapter 5 of Programming Arduino by Simon Monk — Start Project 7 (Keyboard Instrument)
- Friday, Oct. 8 — Embellish Project 7 — Start Project 8 (Digital Hourglass)

Week 7 — Digital Hourglass, Pinwheel, Power Transistors

- Tuesday, Oct. 12 — Embellish Project 8 (Digital Hourglass) — Start Project 9 (Pinwheel)

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Week 8 — Power Transistors and Pulse Code Modulation — The Traitorous Eight

- Tuesday, Oct. 26 — Power Transistors — Biasing transistors — Pulse Code Modulation — Finish Pinwheel — Start Zoetrope (Project 10)
- Friday, Oct. 29 — Finish Zoetrope — Understanding npn transistors — Midterm Course Evaluation and Planning — Read Traitorous Eight and the Birth of Silicon Valley

Week 9 — Midterm and Start Internet of Things

- Tuesday, Nov. 2 — Midterm — Discuss Traitorous Eight and the Birth of Silicon Valley
- Friday, Nov. 5 — Discuss Bit Shift Operators and Logical And Operator as Introduced on Midterm — Midterm Solution: Digital Counter Code and Digital Counter Circuit — Discuss Extra Credit Problem on Midterm — Establish Internet of Things (IoT) Cloud Account — Activity 1 from IoT Kit

Week 10 — Continue Internet of Things

- Tuesday, Nov. 9 — Activities 2 and 3 from IoT Kit — Putting Data in the Cloud
- Friday, Nov. 12 — Activities 4 and 6 from IoT Kit — Remote Triggers — Capacitive Sensor and Passive Infrarad Sensor

Week 11 — Continue Internet of Things — Start Web Servers (HTTP, HTML, APIs, and JSON)

- Tuesday, Nov. 16 — Activities 7 and 8 from IoT Kit — Interacting with the Cloud, Controlling Relays
- Friday, Nov. 19 — Activity 9 from IoT Kit — Start Web Servers — HTTP and HTML

Week 12 — Finish IoT Kit Activities — Finish Web Servers (HTTP, HTML, APIs, and JSON)

- Tuesday, Nov. 23 — Activity 10 from IoT Kit — Finish Web Servers — APIs and JSON

Week 13 — Start Special Projects

Teams and Projects (teams of 2 persons, each building 2 projects) — Carmen and Jacob: Upper Reservoir Level and Power Consumption Monitors; Chenyi and Brandon: Pasteurization Temperature Monitor and Greenhouse Temperature Alarm

- Tuesday, Nov. 30 — Start Special Projects
- Friday, Dec. 3 — Continue Special Projects

Week 14 — Finish Special Projects

- Tuesday, Dec. 7 — Continue Special Projects
- Friday, Dec. 10 — Finish Special Projects

Week 15 — Present Special Projects

- Tuesday, Dec. 14 — Present Special Projects 11:45-12:15 Main Building Main Room