Massachusetts Institute of Technology
Department of Electrical Engineering and Computer Science

6.117 Introduction to Electrical Engineering Lab Skills

IAP 2020 (January 15 – January 31)

Course information

Staff

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Overview

This course is designed to introduce students to the fundamentals of practical electrical engineering (EE) in a relaxed, project-oriented environment. There are no prerequisites for this class; the only requirements are creativity and an interest in EE. Due to the limited availability of lab resources, **enrollment in this course is limited to 17**, with priority given to freshmen.

Prerequisites

None

Lectures

Lectures will be held on **Monday and Wednesday, from 2:30 – 4:00pm** in **4-231**. **Attendance at all lectures is mandatory**.

Labs

All lab work should be completed **in the 6.117 lab space (38-600)**. There are three lab sections:

- Section 1: **Monday/Wednesday, 4:00 – 7:00pm**
- Section 2: **Tuesday/Thursday, 1:00 – 4:00pm**
- Section 3: **Tuesday/Thursday, 4:00 – 7:00pm**

Students will be assigned to their choice of section if possible.

Grading

This course is offered for 6 units of credit. Grades will be assigned on a **P/D/F scale**. All students who complete the lab assignments in good faith, attend all lectures, and prepare a final presentation should expect to pass.

Course material

Objectives

The 2018 Undergraduate Perceptions Survey revealed a significant difference in the perception of EE at MIT between people internal to and external to the department.[1] This course is intended to mitigate that difference by providing opportunities for students to engage with EE in a project-oriented environment and establishing a community of like-minded individuals interested in EE as a major or for personal projects. This course provides a comprehensive overview to practical EE through **lectures, labs and a design project**.

[1] https://ir.mit.edu/undergrad-perceptions-2018

The lectures will introduce students to **basic circuit techniques**, including Kirchoff's laws (KVL and KCL), intuitive analysis and simulation. The lab assignments are designed to familiarize students with the **use of EE lab equipment**, including power supplies, oscilloscopes, function generators and spectrum analyzers.

Following the completion of two lab assignments, students will work on a larger design project assignment. The design project is designed to expose students to more **complex systems while providing structured outlets for creativity**. While all students will work on the same assignment, certain components of the project will be open-ended and will require students to engineer unique solutions. Course staff will be available throughout the course and will provide guidance to students during the labs and project.

Lectures

A tentative schedule of lectures is as follows:

- Lecture 1 (Wednesday, January 15): **Introduction and basic circuit theory**
  - Course overview and logistics
  - Common acronyms, units, and symbols; voltage and current
  - Passive circuit elements: resistors, capacitors, inductors; KVL and KCL
  - Lab equipment overview, lab safety, prototyping (demo)
- Lecture 2 (Monday, January 20): **Intermediate circuit theory, active components**
  - Impedance and passive filtering (low-pass, high-pass, band-pass, band-reject)
  - Active components: LEDs, BJTs, MOSFETs, Op-amps
  - Op-amp circuits: Inverting amplifier, non-inverting amplifier, second-order filters
  - Audio amplification, crossover distortion, push-pull output stage (demo)
- Lecture 3 (Wednesday, January 22): **Digital circuits, power supplies, regulation**
  - The digital abstraction; basic logic gates, flip-flops, shift registers
  - Voltage regulators, power supplies, switching converters (demo)
  - Bistable multivibrator, LM555 timer circuits, LM567 tone detector
  - Design project overview, infrared communications and transimpedance amplifiers
- Lecture 4 (Monday, January 27): **Physical design considerations**
  - Schematic capture, component selection, system coexistence
  - PCB layout and fabrication process, routing considerations
  - Parasitic capacitance, inductance, resistance, power distribution and decoupling
  - Circuit simulation in LTSpice (demo)
- Lecture 5 (Wednesday, January 29): **Radio frequency (RF) and communications; conclusion**
  - Frequency domain representations, Fourier transform, spectrum analysis
  - Modulation (AM, FM, PSK, QAM), mixing, convolution and demodulation (demo)
  - Antenna theory, distributed-element components, RF design considerations
  - Course conclusion, 6-1/6-2 major overview

Each lecture includes a demonstration of a key EE principle. The demonstrations are intended to build intuition for the material and show proper use of lab equipment.

Labs

Students will complete two introductory lab assignments prior to the design project. Each lab will include instructions on how to conduct the lab as well as a short write-up assignment. Both the lab and the write-up are designed to be **completed during one 3-hour lab section**.

The first lab is designed to introduce students to basic **EE lab equipment and standard lab procedures**. Exercises will include measurements with digital multimeters (DMMs) and oscilloscopes, basic function generator operation, and construction of a simple oscillator using the LM555.

The second lab will cover **intermediate circuit techniques** presented in Lecture 2. Exercises will introduce active components, including common-emitter BJT amplifiers and simple op-amp circuits (inverting amplifiers, non-inverting amplifiers and second-order filters). Students will construct a discrete Class AB audio amplifier using a push-pull BJT output stage.

Design project

The design project will be distributed following the completion of Lab 1 and 2. The design project is intended to allow students to engineer a complex, mixed-signal system. The design project will incorporate principles from Lecture 1 – 3 and will feature **open-ended subproblems** to which students will implement their own solutions. After completing the design project, students will have designed and assembled a self-contained audio amplifier with remote lock/unlock capabilities. The digital lock can be repurposed to control a variety of devices.

The design project will be completed in **three lab sessions**. During the first session, students will complete the digital lock/unlock circuit. The digital lock will be implemented using a shift register and a digital comparator, which will activate when a specific 8-bit password is presented at the input. During the second session, students will complete the remote-control circuitry. Remote functionality will be implemented with a 40 kHz amplitude-modulated (AM) infrared receiver/transmitter system. During the third session, students will assemble the project and finish any remaining items from previous sessions.

Timeline

A tentative schedule of all lectures, labs, and assignments is as follows:

January 2020		**W** 15	**R** 16	**F** 17	**M** 20	**T** 21	**W** 22	**R** 23	**F** 24	**M** 27	**T** 28	**W** 29	**R** 30	**F** 31
Section														
Lecture	1	L1			L2		L3			L4		L5		Pa
Lab	1	L1			L2		P			P		P		Pa
	2		L1			L2		P			P		P	Pa
	3		L1			L2		P			P		P	Pa

Key		
	Ln:	Lecture n
	L1:	Lab 1
	L2:	Lab 2
	P:	Project
	Pa:	Panel

Following the completion of the course, an EE opportunities and experiences panel will be held as an opportunity for first-year students to deepen their knowledge of Course 6-1 and EE-related opportunities and careers. Food will be provided. The panel will be held on **Friday, January 31, from 1 – 3pm in 4-231**.