# EE40Lx – Electronic Interfaces: Bridging the Digital and Physical Worlds

## Welcome

Our modern life is filled with devices that communicate between the digital and physical worlds. Everything from the automobile to the refrigerator is highly instrumented, taking measurements from many sensors and analyzing the data to make automatic decisions. At the heart of this activity is the interface: the electronic front end that measures a physical signal, filters it, then sends the information to a digital computer.

Through EE40Lx, you will build a robot around the MSP430G2 LaunchPad, learning the fundamental principles underlying these electronic interfaces. This journey starts small – a few craft sticks, springs, and a voltage regulator – but eventually you will have a complete robot capable of bouncing around the environment while responding to light and sound inputs. We are excited to be your guides for this learning experience!

## Instructors


- Michel M. Maharbiz
  Associate Professor
  Department of Electrical Engineering and Computer Science
  University of California, Berkeley

- Tom J. Zajdel
  Graduate Student Researcher
  Department of Electrical Engineering and Computer Science
  University of California, Berkeley


## Objectives

Analyze, design, build and test electronic circuits, and understand their capabilities and limitations.

1. Understand fundamental circuit principles
   - Lumped circuit model (Kirchhoff's laws)
   - Energy storage (capacitors and inductors)
   - Time and frequency domain signal representations
   - Analog and digital signals, conversion
2. Design, build, and test electronic circuits
   - Laboratory practices (breadboarding, test equipment)
   - Guided laboratories + robot project

## Prerequisites

High school level algebra and trigonometry is required. High school physics is recommended, but not required. Some exposure to computer programming would be useful for those who want to dive further into modifying the robot's code design. The most important requirement is a willingness and desire to build things with your hands!

## Course Format

The course is divided into 8 modules which will all be released once the course begins. You will be able to go through the modules at your own pace, but the course will end after 15 weeks. We urge you to follow along the videos with your own kits and build the circuits along with us. Each module will consist of the following content types:

- *Lecture Videos*
  Cover essential theory in a traditional, conversational format
- *Bench Videos*
  Demonstrate physical circuits that you can build and test
- *Debug Videos*
  Show common problems you may encounter while building the circuits, how to diagnose them, and how to fix them
- *Notes*
  Short written one-page texts that supplement the information presented in the videos
- *Quizzes*
  These short problems are sprinkled throughout the module to give you an opportunity to test your understanding. Answering these quiz questions is not required to complete the course but participation will help the learning process.

## Robot Project

The lab-based videos presented in the class largely concern the building of a craft-stick vibrating hopper robot controlled by the MSP430G2 LaunchPad. This robot as completed in the course has the following subsystems:

- Voltage regulator
- Photocell front ends (2)
- Speaker driver
- Microphone front end
- DC motor drivers (2)

These systems communicate with the MSP430G2 LaunchPad in order to allow the robot to move in response to its environment. Refer to the Robot Project document for details.

## Grading

Grading will be based on Problem Sets and a peer-graded Final Project.

- Problem Sets (6): 60 %
- Final Project: 40 %

We will grade the course on a pass/fail scale. You need a total score of 60% or above for a passing grade. The Final Project points will be awarded for students who successfully assemble the robot. Notice that these points are not required to pass the course, but 100% completion of the problem sets is required for students who do not attempt the robot labs to pass the course.

Students who earn a passing grade will receive a certificate of completion issued by Edx.

## Course Outline

| Section | | Robot Part |
|---|---|---|
| **Module 0: Prologue** | | |
| **0.1** | **Course Outline** | |
| **0.2** | **What are Interfaces?** | |
| **0.3** | **Robot Project** | |
| **0.4** | **Breadboards** | |
| **0.5** | **MSP430 Programming** | |
| **Module 1: Fiat Lux!** | | |
| **1.1** | **LED Circuit** | |
| **1.2** | **Water Flow Analogy** | |
| **1.3** | **Verifying Circuit Laws** | |
| **1.4** | **Voltage Regulator** | **Voltage regulator** |
| **Module 2: Resistors** | | |
| **2.1** | **Resistors** | |
| **2.2** | **Ohm's Law** | |
| **2.3** | **Variable Resistors** | |
| **2.4** | **Wheatstone Bridge Analysis** | **Photocell Front End** |
| **Module 3: Amplifiers** | | |
| **3.1** | **Comparators** | |
| **3.2** | **Comparator Front End** | |
| **3.3** | **Amplifier Models** | **Speaker Driver** |
| **3.4** | **Speaker Driver** | |
| **3.5** | **Ideal Amplifier Model** | **Electret Mic Front End** |
| **3.6** | **Microphone Front End** | |
| **Module 4: Capacitors** | | |
| **4.1** | **Capacitors** | |
| **4.2** | **Capacitance** | |

| | | |
|---|---|---|
| 4.3 | Bypass Capacitors | Voltage Regulator Revisited |
| 4.4 | Three Observations | |
| 4.5 | RC Circuits | |
| 4.6 | Filters | |
| 4.7 | Phasors | |
| 4.8 | Microphone Amp Revisited | Electret Mic Front End Revisited |
| Module 5: Inductors | | |
| 5.1 | Inductors | |
| 5.2 | Inductance | |
| 5.3 | Four Observations | |
| 5.4 | RL Circuits | |
| 5.5 | DC Motors and Diodes | |
| 5.6 | Phasors Revisited | |
| Module 6: Transistors | | |
| 6.1 | Switches | |
| 6.2 | FETs | |
| 6.3 | BJTs | Motor Driver |
| 6.4 | Motor Driver | |
| Module 7: Epilogue | | |
| 7.1 | Final Robot | Final Project |
| 7.2 | Extensions | |
| 7.3 | Thank you! | |