Course Syllabus

ENEE 408L: Electric Guitar Design Capstone
Prof. Bruce Jacob

Basic Information

Time & Place

Lecture/Lab: Wed 10:00am–2:00pm, AVW-1424

Professor

Bruce L. Jacob: AVW-1333, blj@ece.umd.edu
Office hours: *Open-door policy*

Class Home Page

http://www.ece.umd.edu/courses/enee408L

Class Email List

enee408l-0101-fall18@coursemail.umd.edu

Class Schedule

This is a weekly schedule of my hours, including class time and scheduled office hours, but also including other things that make me unavailable. It is subject to change.

	MON	TUE	WED	THU	FRI
9–9:30					
9:30–10					
10–10:30					
10:30–11					
11–1:30					
11:30–12			**ENEE 408L** Lecture AVW-1424		
12–12:30					
12:30–1					
1–1:30					
1:30–2					Weekly meetings with graduate students
2–2:30					
2:30–3					
3–3:30					
3:30–4					
4–4:30					
4:30–5					

Course Overview

Modern electric guitars contain both EE and CE components; the fundamentals are EE-based, but an increasing number of current designs incorporate CE-based concepts such as active digital control circuits, digital signal processors, and many embedded digital effects units. This class will teach the skills necessary for good product design and development in the real world, using as a motivating example the electric guitar, and integrating computer-engineering skills and concepts.

The course will build upon previous disciplines and development skills students have learned, such as circuit design and test, analog and digital circuit components and their uses, FPGA-based design and implementation, as well as the interaction between magnetic fields and electric currents. It will also introduce, briefly, new skills such as PCB design, fabrication, and assembly: students will design circuits and circuit boards; they will have those boards manufactured; they will assemble the boards, solder the parts, and wire them into prototype designs.

Using these disciplines as a base, the course will focus on *design*, an important discipline in which practitioners identify technical needs or problems to be solved, recognize constraints, evaluate multiple alternatives, select one alternative for implementation, and then characterize the final implemented design solution—both against the desired outcomes (e.g., design validation, quality assurance) and against existing or competing design alternatives. Design has been championed in the popular culture lately, perhaps most famously in Apple's approach, which is to simplify a design to its most important essence ("A Thousand NOs For Every YES"), distilling one's design choice down to a minimal set of critical features rather than piling on as many features as possible.

Students will learn fundamentals of electric guitars and then combine this with their prior knowledge of analog & digital circuit design, FPGA implementation, as well as PCB fabrication, to design and build a real-world system, evaluate it, and communicate the results both as a written report and as an oral presentation.

Prerequisites

The course has the following prerequisites:

- ENEE205 — *Electric Circuits*
- ENEE245 — *Digital Circuits and Systems Laboratory*
- ENEE303 — *Analog and Digital Electronics*
- ENEE307 — *Electric Circuits Design Lab*

In addition, a familiarity with the operation and physical structure of an electric guitar is necessary. Students will be taught the fundamentals of how to wire the guitar; a student need not have wired up a guitar prior to the class.

Course Materials

The required text for the course:

- *Hackers & Painters*, by Paul Graham. A book about developing code and starting up companies. It is especially relevant because it goes deep into the thinking required for the technical design work behind a successful start-up company. It is written by one of the two founders of Viaweb, the company that built the engine that now powers Yahoo! Stores.

Class Projects

Several projects will be assigned during the term, which form the bulk of the course grade and each of which will require a substantial time commitment on your part.

- Project 1: *Full electric guitar wiring & experimental measurement*

  Students will wire up guitars from scratch, test them, and them perform experiments on them to answer several questions of reverse-engineering, thereby raising some questions of implementation that can lead to novel designs for capstone projects.

- Project 2: *Advanced switching & PCB design, implementation*

  Students will learn the Eagle CAD tool for PCB design, develop circuit boards, implement novel circuit components to solve an advanced switching problem, have their boards fabricated, and perform their own assembly.

- Project 3: *Student capstone design*

  Students will work in teams to propose an idea, implement it, test it, and write up their work and final conclusions.

Capstone Project & Report

Students will form teams, each of which will propose an idea and implement it. The project will present an implementation given realistic constraints and perform a formal comparison with prior-art designs.

Students will submit a formal report. Reports must use the *ECE Capstone Design Report Template* and include the following components:

- Identification of problem, need, or goal
- Description of design constraints
- Description of various design alternatives, analysis of each
- Characterization of final implementation vs. original design requirements (evaluation of success) and existing alternatives

Students will also give oral presentations on their designs.

Grading Policy

Final grades will be based on the total of points earned on the projects and exams. The tentative point breakdown is as follows:

- Project 1: 20%
- Project 2: 10%
- Project 3 work: 40%
- Project 3 report: 20%
- Project 3 oral presentation: 10%

Tentative Lecture Schedule

Week of	Subject/s	Lab
Aug 27	Intro to course, The physics of sound	Waves, volts, amps, soldering
Sep 3	Electric guitar fundamentals, Circuit fundamentals, Audio fidelity	PCB design & advanced switching
Sep 10	Advanced switching, Reverse engineering	*PCB design & advanced switching, cont'd*
Sep 17	Really advanced switching, Thoughts on student projects	Full guitar wiring
Sep 24	Advanced tone circuits, Thoughts on student projects	*Full guitar project, cont'd*
Oct 1	Pickup construction	Student-defined project
Oct 8	Related issues: PCB-design tools	*Student-defined project, cont'd*
Oct 15	**Preliminary Design Presentations**	***Preliminary Design Report due***
Oct 22	Related issues: Woods	*Student-defined project, cont'd*
Oct 29	Related issues: Characterization of materials	*Student-defined project, cont'd*
Nov 5	Related issues	*Student-defined project, cont'd*
Nov 12	Related issues	*Student-defined project, cont'd*
Nov 19	Related issues	*Student-defined project, cont'd*
Nov 26	Related issues	*Student-defined project, cont'd*
Dec 3	Related issues	*Student-defined project, cont'd*
Exams	**Project Presentations**	***Final Project Report due***

Special Needs

If you have a documented disability that requires special needs, please see me as soon as possible, and certainly no later than the third week of classes.

Educational Objectives/Student Outcomes

A. Apply key concepts in physics, basic analog & digital circuit design, E&M, and FPGA implementation, introduced earlier in the undergraduate electrical engineering curricula.

B. Perform design analysis of alternatives, based on desired outcomes and implementation constraints. Characterize and evaluate alternatives, rank them, and identify one target implementation for the group project. Indicate the desired design requirements of the chosen implementation.

C. After selecting an appropriate design solution/implementation, partition and distribute design tasks within each team.

D. Analyze, design and optimize designs using theory presented in class. Use computer-aided design tools such as Eagle and Xilinx to implement designs; use lab equipment to characterize and optimize implementations.

E. Student groups will communicate to the class both mid-semester preliminary design problems as well as final project results.