(MIT D-Lab) EC.751 / EC.793 (G)

Hardware Design for Development.

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Course Website: https://dlabmobiles4dev.mit.edu/

Revised: Fall '24 (3-2-7)

Location: N51-350

Class Time: 2:00-5:00 PM Wed

Lab Time: 2hours/week TBD

Office Hours: After class & by appointment

HELO EVERYONE! Welcome to **Hardware Design for International Development**! We're so excited to have you here! This class focuses on using electrical and mechatronics design in the context of underserved communities to solve specific challenges related to the United Nations Sustainable Development Goals. The class focuses on teaching robust, scalable, reliable electrical hardware design. Lectures are generally tailored to the specific projects that will be completed in class that semester, this topics for this fall are listed below.

But stepping back for a second, this class was design to teach you how to design an electrical system from scratch. The course has a number of labs that provide hands-on design, bring-up, fabrication, and testing experience with a specific focus on design for robustness, design for integration with mechanical systems, design for serviceability and manufacturability, and design for harsh or unpredictable environments. The class has a constrained, term-long design project where you work with a partner to design, build, and field test a fully capable system.

Additionally, students will learn the participatory design process and work in teams to apply participatory design principles to specific projects developed by community innovators in urban and rural areas of Uganda, Tanzania, and Ghana. Optional travel will occur over IAP 2025 with D-Lab partners in the field.

Some class topics include: data collection and analysis using IoT, cellular and data-logging, embedded systems with the STM32 microcontroller, sensing, power electronics and power conversion, batteries and solar, motors, thermal management systems, parts sourcing and component testing, PCB design, up-cycling and re-using components, system-level electronics design.

Course Materials & Readings

Note that course materials can be found on https://dlabmobiles4dev.mit.edu/ as well as the class Canvas. Readings will be periodically assigned from the textbook (available online).

Required Textbook

Practical Electronics for Inventors, 4th Edition, Scherz, Monk (https://archive.org/details/practical-electronics-for-inventors-4th-edition-by-paul-scherz-simon-monk-z-lib.org)

A Note on Prerequisites

Note that this class has no pre-reqs, and we will stay true to that. We will teach you how to design an electrical system from scratch using basic physics calculations to size components and predict performance. However, if you've never done electronics before we will be providing additional resources for you to work through outside class. We will be assuming some knowledge on voltage, current, Kirchoff's laws, series and parallel circuits, RC/RLC/LC circuits and modeling. Classes that teach this include 8.02/6.002/and 2.678, please see the syllabi for those classes or read out to us for resources.

Please come talk to us so we can help you do well! We want you to enjoy this class, we want you to learn as much as you possibly can so come work with us so we can make sure you do!

Course Projects

The course projects this year are focused on energy conversion, electrification, IoT, and waste processing. You will work in teams on one of the projects below with travel to partner countries the following IAP or Summer to implement the projects. Student teams will also meet with partners weekly for collaboration.

- **Vehicle Electrification**– Electrification of Ambulances for improved healthcare access (Moving Health, Ghana).
- **Electric Vehicle Use and Ride Tracking**– Development of an STM32-based cellular connected tracking system for electric delivery vehicles (Greenfoot, Tanzania)
- **Engine Testing and Maintenance Tracking**– Testing engines for reliability while developing a STM32-based tracking system for oil changes, maintenance, and other issues (Imaratech, Tanzania)
- **Plastics Recycling**– Developing a machine to create 3D printer filament, or other useful products from small plastic waste shards (Green Venture, Tanzania)
- **TBD** – (Rhino Camp, Uganda)

Deliverables

The large course deliverables are listed below in addition to any reading assignments, or in-class work that may be assigned. Please note that late work will result in a half letter grade reduction, and an additional half letter grade for each week after the first day it is late.

Midterm Deliverables (due by Oct 23)

- You will have a midterm design review with the course staff which includes a design of the full system and circuit board for manufacturing. This review is designed to ensure your board or system is ready for manufacturing.

Final Deliverables (due Finals Week)

- A final (working) prototype of the system designed throughout the course of the semester ready for implementation in-country during the following trip and any associated documentation
- A brief blog post (1-2 paragraphs) for the MIT D-Lab blog and website
- A final paper detailing the design process (in the style of IEEE GHTC)– https://ieeeghtc.org/

D-Lab Showcase:

Every year, D-Lab has a wonderful showcase/student celebration where you get to share your projects with other classes! This year the showcase is 12/5 from 7-9PM in D-Lab's room 310. Your attendance is not required, but it is greatly encouraged.

Course Schedule and Labs

Week	Lecture	Lab	Deliverables
9/4	• Intro to D-Lab & Class • Intro to "Design for Second Life Innovations Project" • Class Projects, System Overview • Media Release Form • Travel Survey	• Project Selection, Team Formation	• Team Selection • Media Release Form • Skim Chapter 2 and Chapter 3 if you need Review • Read Chapter 7 • Download Software
9/11	• Intro to Local Innovators • Participatory Design Process 1 • System-Level Electrical Design • A Number of Interesting Circuits	• Introduction to KiCAD and PCB Design • EE Lab Tools	• Travel Schedule • Read Chapter 13
9/18	• Circular Economy & E-Waste • Life Cycle Assessment • Microcontrollers and Communications	• PCB Design: Component Selection, Schematic Capture I	• Homework 1 • Read Chapter 6 • Read Section 12.9
9/25	• Participatory Design Process 2 • Sensors, and Devices	• PCB Design: Schematic Capture II	• Homework 2 • Read Chapter 11 • Skim Section 12.5 • Skim Section 4.5

10/2	• Carbon Credits • Power Conversion, and Batteries	• PCB Design: Layout I	• Homework 3 • Read Chapter 15
10/9	• Participatory Design Process 3 • Motors, and Motor Control	• PCB Design: Layout II	• Read Appendix A
10/16	• Solar and Grid Sources	(--)	• Homework 4
10/23	• **Mid-Term Presentations**		• Homework 4
10/30	• Participatory Design Process 4 • Debugging Electrical Systems	• Developing Testing Systems • Testing Batteries	
11/6	• Microcontroller Programming • IoT	• Interfacing with SD Cards and Cellular	• Homework 5
11/13	• Disassembling and Re-using Electrical Components	• Electronics in an Engine • Microwave Spot Welder	
11/20 (Drop Date)	• Component Sourcing, Supply Chains	• Design for Scale (harnessing, connectors, cost, etc.)	
11/27 (Fall Break)	• **No Class! Enjoy Break!**	–	
12/4	• Component Sourcing, Supply Chains	• Project Work	
12/5 (Not Mandatory)	• D-Lab Showcase: 7-9PM Room 310	–	
12/11	• Final Presentation	• Project Work	• Final Presentation
12/16-12/20 (Final Exams)	• Finish Up Projects + Trip Prep	–	

Grading Policy

Attendance and Participation

This is a 12-unit class: 3 hours each week will be spent in class, 2 hours per week will be spent in lab, and 7 hours will be spent on project team meetings, readings, homework, and developing the projects.

Grade Distribution

- In-Class Participation: 10%
- Lab Participation: 10%
- Assignments: 20%
- Mid-Term Project: 10%
- Final Project: 30%
- Attendance: 20%

Homework must be posted on Canvas before the beginning of the class on the day that it is due. If you anticipate problems handing in an assignment on time, contact the instructors in advance; late work will be reduced by half a letter grade each day unless the student has an extension. Extensions will always be granted upon request (with a new due date stated clearly at the time), and no reason needs to be given to request an extension.

Class attendance and participation are crucial due to the interactive nature of the sessions, which include discussions, hands-on activities, prototyping, and user testing. As most work is team-based, a student's absence can impact the entire group. Attendance is mandatory. Students who miss a class should contact the instructors and complete a make-up assignment by interviewing a classmate about the missed session and writing a one-page summary and reflection.

Students are allowed a maximum of two unexcused absences; each additional absence will result in a 1% deduction from the final grade. Missing a weekly team meeting will result in a 2% deduction. The course is graded on an A/B/C/D/F scale. Given the global impact of your work, a high level of commitment is expected for project deliverables, which will influence your participation grade.

Course Policies

Classroom Policies

Students are permitted to use notebooks, laptops, or any medium they wish for lecture, labs, and learning as long as it is not distracting to other students. We ask students wear closed toed shoes and tie long hair back during the lab portion of the classes for safety reasons.

Diversity Statement

We consider this classroom to be a place where you will be treated with respect, and we welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, ability – and other visible and nonvisible differences. All members of this class are expected to contribute to a respectful, welcoming, and inclusive environment for every other member of the class.

Plagiarism Statement

Plagiarism, the use of writings or ideas of another as one's own without acknowledging that source, is unacceptable and may result not only in a 0 on the assignment, but having a letter placed in your file at the Institute. The use of AI software or apps to write or paraphrase text for your paper is not allowed.

Use of AI Tools

Please note that for the purposes of the learning environment, the use of AI tools such as Google Co-Lab, ChatGPT, or other AI Code or Design generation platforms is **not permitted.**