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MedTech Prototyping Skills (BME254L) Syllabus

Personnel

Instructor

Dr. Mark Palmeri

- Email (slower): mark.palmeri@duke.edu
- Ed Discussion (private message, TAs included)
- Office Hours: Email Me!

Teaching Assistants

- Carson Pazdan (`cbp31`)
- Lauren Kenselaar (`lbk18`)

- Emily Song (`ecs94`)

> **Tip**
>
> Questions that can be answered by Dr. Palmeri or a teaching assistant should be posted on Ed Discussion.

Course Times & Locations

Lecture: Tuesday & Thursday, 11:45-13:00, Wilkinson 132 (Panopto recorded)

Lab: As needed, Fitzpatrick B209 (Door Code: 1-4-2)

There are no formally scheduled lab sections, but you will need to use the lab equipment to perform testing of your devices. Your TAs will announce times when they will hold lab hours. Lab is available whenever classes are not scheduled in the space (posted on the lab door).

> **Important**
>
> Please review the lab policies before using the lab for the first time this semester.

> **Warning**
>
> No food or drink is allowed in the lab! Failure to adhere to this policy will have consequences on your course participation grade.

Course Objectives

This course focuses on developing medical device prototyping skills that will be used in future project and design courses, with a focus on preparing our students for positions in the medtech industry. Students will work individually to complete design tasks that will be tested to quantitative specifications. Students will gain hands-on experience with device fabrication, debugging, testing and failure analysis.

Upon completion of this course, students should be able to:

- Software version control (`git`)
- Perform functional decomposition and express as a stage diagram (UML)
- Utilize ECAD (`KiCad`) for:
  - Electronic schematic capture

  - Printed circuit board (PCB) layout
- Modular breadboarding of circuits to translation to testable PCBs
- Design a battery-powered device that:
  - Accepts analog and digital user input
  - Outputs analog and digital outputs
  - Passes testable specifications to 95% CI
- Implement electronic logic on microcontroller (Arduino framework)
  - Modular / testable code development in C
  - Interupt Service Routines
  - Pulse Width Modulation
  - State Machine
- Utilize CAD (`Onshape`) for:
  - Device enclosure design with UI/UX considerations
  - Input / Output considerations
  - Size / weight constraints
  - Preparation of mechanical drawings
- 3D printing of designs
  - Assembly of discrete enclosure pieces
  - Use of mechanical fasteners
- Write technical analysis reports in Jupyter notebook

Prerequisites

Mandatory

- Computational Methods in Engineering (EGR103) or equivalent
- Fundamentals of Electrical and Computer Engineering (ECE110L) / Biomedical Electronics Measurements (BME290L) or equivalent

Learning Management System

We will be using Canvas as the learning management system for this course. It will host the syllabus, which will have hyperlinks to all lecture content and lab assignments.

Duke's GitLab server will be used for most course lab exercises, and code-related questions will be submitted to Dr. Palmeri / TAs using GitLab Issues.

Ed Discussion will be used for general course questions and discussion.

Class Schedule

This class is organized in a sequence of modules. Specific details surrounding dates for assignments associated with each module will be posted to Gradescope.

This course uses a version of Mastery Learning, where "mastery" of a given module is necessary to progress onto the subsequent module. Quizzes are used to evaluate "knowledge"; lab exercises are used to demonstrate application of skills. In this course, assignments of later modules depends on the successful completion of earlier modules.

Learning Modules

- MedTech Skill Overview
- Event-Drive State Machines
- Computer Aided Design (CAD) (`Onshape`)
- Lightbox Project (Kanban Board)
- ECAD (`KiCad`)
  - Schematic Capture
  - SPICE Modeling
  - PCB Layout
- Version Control (`git`)
- Firmware Development
  - C Programming Overview
  - State Machines (`switch` / `case`)
  - Button Event ISRs
  - Analog-to-Digital Conversion (ADC)
  - Pulse Width Modulation (PWM)

Attendance & Participation

Class participation in both lecture and lab time is strongly encouraged. Lecture will be used to provide skill overview and live demonstrations, many of which will kickstart your efforts for your project. Lab time will provide you access to equipment and the TAs for assistance.

Students are responsible for obtaining missed lecture content from other students in the class. All lecture slides/presented content will be made availabe online (Canvas/Gitlab), and lectures will be recorded via Panopto and posted to Canvas.

Participation on Ed Discussion is also encouraged, in the form of:

- Asking questions about the course material (ideally, publicly, so that others
- can benefit (Anonymous okay))
- Answering questions from other students
- Sharing interesting articles or resources related to the course material

Assignments & Grading

Grading

There will be quizzes / completion surveys, and lab exercises associated with some of the learning modules (40%), all of which will be submitted through Gradescope.

The course project will have regular milestones throughout the semester, culminating in a final functional device that you will present and an associated technical report testing device function (50%).

Class participation (10%) will be evaluated based on your engagement in the lecture/lab setting, demonstrating good lab practices and submitting assignments on time for feedback.

All assignment grades will be posted to Canvas/Gradescope throughout the semester to track your performance.

Table 1: Grade Distribution

Grade Category	Relative Percentage
Quizzes / Lab Modules	40%
Project	50%
Participation	10%

Course Grade

This course is not "curved" (i.e., a distribution of grades will not be enforced), and a traditional grading scheme will be used (e.g., 90-93 = A-, 94-97 = A, 97-100 = A+). Participation throughout the semester will influence rounding up/down for fractional grades.

Failing the course can happen with a cummulative score < 60 (D-) or not completing all of the assignments.

Regrades

Any regrading requests need to be made **within one week of grades for a given assignment being released**. You must make the request via Gradescope and provide a description of why you feel a regrade is appropriate. Requesting a regrade could lead to additional loss of credit when an assignment is re-evaluated.

Some assignments will have an opportunity to be resubmitted based on grading feedback at the discretion of Dr. Palmeri.

Late Policy / SDAO Accomodations

Late submission windows will be available for some assignments and should be used to accomodate acute illness, travel, high workload from other classes and other unforeseen circumstances. This late submission window can be utilized without penalty and without prior approval.

Students with SDAO accomodations for extended time on assignments can use this extended late submission window for all assignments.

Any assignments submitted after the late submission window will only be accepted for partial credit at the discretion of Dr. Palmeri or if prior approval was sought **before the original due date**. Requests for late submission accomodation will be considered on a case-by-case basis and will result in a deduction in the course participation grade.

Duke Community Standard

All students are expected to adhere to all principles of the Duke Community Standard. Violations of the Duke Community Standard will be referred immediately to the Office of Student Conduct. Please do not hesitate to talk with Dr. Palmeri about any situations involving academic honor, especially if it is ambiguous what should be done.

FAQ

Can I collaborate with other students?

Engineering is inherently a collaborative field, and in this class, you are encouraged to work collaboratively on your projects. That being said, all of the work that you submit must be generated by you and reflect your understanding of the material.

> **Note**
>
> All resources used in your projects that were developed by another person or company must be properly acknowledged using comments in your code / reports.

Can I use AI?

The use of artificial intelligence is a rapidly developing resource / tool in engineering. In software development, there are many levels of AI-assitance available. Such form of assistance include the IntelliCode tools and GitHub CoPilot (free to students through the GitHub Education program). These tools can be leveraged to help with syntax. **You are, however, strongly cautioned to not rely on these tools for logical implementation.**